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Biology of Shovelnose Sturgeon, Scaphirhynchus platorynchus, in the Lower Platte River, Nebraska

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BIOLOGY OF SHOVELNOSE STURGEON, *SCAPHIRHYNCHUS PLATORYNCHUS*, IN THE LOWER PLATTE RIVER, NEBRASKA

by

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BIOLOGY OF SHOVELNOSE STURGEON *SCAPHIRHYNCHUS PLATORYNCHUS* IN THE LOWER PLATTE RIVER, NEBRASKA

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Because of declines in North American river sturgeons and the federal listing of pallid sturgeon (*Scaphirhynchus albus*) in 1990, understanding sturgeon biology has become extremely important. Sturgeon were collected at six sites in the lower 160 km of the Platte River, Nebraska from July through October, 1995 and April through September, 1996 using gill nets, seines, and larval drift nets. Habitat was measured in all sample areas and sturgeon were identified, counted, measured, weighed, examined for parasites and disease, injected with a PIT tag, and released. During 1996 gut contents were sampled for food habit analysis using pulsed-gastric-lavage, pectoral fin rays were removed for age and growth determination, and seven sturgeon were surgically implanted with radio transmitters to study movements and habitat use.

One hundred thirty one shovelnose sturgeon *Scaphirhynchus platorynchus* were captured ranging from 314 to 680 mm FL with ages from 3 to 8 years. One suspected hybrid (*S. platorynchus X S. albus*) was captured at 750 mm and age 9. Based on monthly comparisons of catch per unit area at each site, it appears sturgeon migrate upstream in the spring and downstream later in the year. Radio-telemetry showed a positive relationship between movement and discharge during 1996. Sturgeon were most frequently found at depths from 61 to 90 cm, mean column velocities from 46 to 75 cm/sec, and bottom velocities from 31 to 45 cm/sec. Chironomids made up the majority of their diet from May through September, 1996. One larval sturgeon was found, but Cyprinidae and Sciaenidae were the most abundant fish found in drift net samples.

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General Introduction

Declines in abundance and distribution of shovelnose sturgeon, *Scaphirhynchus platorynchus,* and pallid sturgeon, *Scaphirhynchus albus* (Snyder 1994), and the listing of pallid sturgeon as a federally endangered species (Dryer and Sandvol 1993) have promoted interest in sturgeon habitat selection, food habits and overall biology. Nearly all recovery priority management areas for pallid sturgeon are associated with major tributaries due to the frequency of pallid sturgeon reports from these areas (Dryer and Sandvol 1993). "Tributaries of the Missouri River are thought to serve as important feeding and nursery areas for many large-river fishes, because they are typically less degraded, have higher habitat diversity, and some still exhibit a natural configuration of sandbars, side channels, and varied depths" compared to channelized sections of the Missouri (Dryer and Sandvol 1993).

The Platte River in Nebraska is a recovery priority management area near its confluence with the Missouri River (Dryer and Sandvol 1993). Pallid sturgeon have been documented in the lower Platte River and are occasionally captured and reported by anglers (Darryl Feit, Nebraska Game and Parks Commission, personal communication). It has been established that a substantial sport fishery exists for shovelnose sturgeon in the Platte River, at and immediately below its confluence with the Missouri (Latka 1994). A creel survey in the lower 160 km of the Platte River found that shovelnose sturgeon comprised 4 and 5.3 percent of the angler catch and ranked fourth and third in abundance in the catch during 1992 and 1993 respectively (Holland and Peters 1994). The importance of the lower Platte River to sturgeon populations prompted the need to collect base-line data.

The goal of this research was to assess the current status and biology of sturgeon populations in the lower Platte River. The first objective was to document the population structure, distribution, and movements of shovelnose sturgeon. The second objective was to document habitat use and food habits of shovelnose sturgeon. The third objective was to determine if the Platte River is acting as a spawning area for sturgeon.

Study Area

The Platte River is a large braided prairie river composed of mostly sandy substrates with over 90% of the river less than 60 cm deep (Peters et al. 1989, Holland and Peters 1994). The Platte River begins at the confluence of the North and South Platte rivers which both have headwaters in the Rocky Mountains. They meet near North Platte, Nebraska, approximately 490 km from the mouth of the Platte. Historically, peaks in annual discharge occurred during May and June as snowmelt from the Rockies found its way down the Platte River Valley (Bentall 1982). In general, the lower Platte is narrower, deeper, and has significantly greater discharge than areas upstream from Columbus.

The lower Platte begins at the confluence of the Loup and Platte rivers near Columbus, NE., approximately 160 km upstream from its confluence with the Missouri River. This section of the Platte gains significant flow contributions from the Loup and Elkhorn rivers, which are both fed by groundwater from the sandhills of Nebraska (Bentall 1982). Long term records beginning in the mid 1900's from the U.S. Geological Survey (Boohar et al. 1995) show that the overall annual mean for daily discharge in the central Platte River near Duncan, Nebraska is 1,791 CFS (above the Loup River confluence). In the lower Platte River it is 4,569 CFS near North Bend, Nebraska (below the Loup River confluence), and 6,869 CFS near Louisville, Nebraska (below the Elkhorn River and Salt Creek confluences). Salt Creek has an annual mean daily discharge of 353 CFS near its confluence with the Platte River at Greenwood, Nebraska (Boohar et al. 1995).

Six sampling reaches were established along the lower Platte River between its confluence with the Missouri River and the mouth of the Loup River near Columbus, Nebraska (Figure 1). Sampling reaches included areas near Columbus, North Bend, Fremont, the mouth of the Elkhorn River, Louisville, and Plattsmouth, Nebraska. Each sampling reach encompassed about 8 km of river, and included at least one perennial tributary. These tributaries were the Loup River and Loup River diversion canal at Columbus, Skull Creek at North Bend, the Fremont Cutoff Ditch at Fremont, the Elkhorn River at the Elkhorn reach, Decker Creek at Louisville, and Zweibel Creek at Plattsmouth.

Chapter 1: Population structure, distribution, and movements of shovelnose sturgeon in the lower Platte River, Nebraska

Introduction

Due to declines in their abundance and distribution (Snyder 1994) much emphasis has recently been placed on research of North American river sturgeons. With the 1990 listing of pallid sturgeon (*Scaphirhynchus albus*) as a federally endangered species, the recovery team identified several research objectives for studying sturgeon populations, including field investigations to determine population status, age and growth, movement patterns, and disease problems within recovery priority management areas (Dryer and Sandvol 1993). These research topics have been reiterated by members of the Mississippi Interstate Cooperative Resource Agreement (MICRA) in their Paddlefish/Sturgeon Strategic Plan (MICRA 1993).

The Platte River near its confluence with the Missouri River in Nebraska is a recovery priority management area. Shovelnose sturgeon (*Scaphirhynchus platorynchus*) have been documented as an important component to the Platte River sport fishery (Latka 1994, Holland and Peters 1994) and occasionally pallid sturgeon are reported by anglers in the lower Platte, from its mouth to the Elkhorn River (Daryl Feit, Nebraska Game and Parks Commission, personal communication). A primary objective of this research was to document population structure, distribution, and movements of shovelnose sturgeon in the lower Platte River, Nebraska.

Methods

Six sampling reaches were established in the lower Platte River (Figure 1). Fish collections were made at each sampling reach from July through October, 1995 and April through September, 1996 by drifting gill nets that were 2 meters deep and either 15.2 or 30.5 meters long. In 1995 nets were made up of four panels of alternating 2.5 and 5.1 cm monofiliment mesh. In 1996 nets included 1.2, 2.5, 5.1, and 7.6 cm bar mesh. Gill nets were drifted with the current and the distance for each drift was estimated visually in 1995 and measured using a rangefinder during 1996. The area of river sampled was calculated for each drift by multiplying the length of the drift by net length adjusted to account for bunching up or tearing of nets as they drifted through channels. Catch per unit area (CPUA) was calculated as the number of sturgeon captured per hectare of river sampled at each site each month. Stationary sets of experimental mesh gill nets were also fished parallel to the current below sandbars for three hours at a time at each sampling reach during 1995. These nets were 46 m long with six 7.6 m panels of 1.9, 2.5, 3.2, 3.8, 5.1, and 7.6 cm bar mesh.

All fish captured were identified, counted, measured, and released. Sturgeon were measured (fork length), weighed (in grams), examined for parasites and disease, and injected with a Passive Integrated Transponder. Pectoral fin rays were removed from sturgeon captured in gill nets during 1996, fish captured by anglers at the Schilling State Recreation Area immediately at and below the mouth of the Platte during April and May, 1996, and also from sturgeon that were found dead at Columbus on July 21, 1996. In the laboratory fin rays were sectioned, mounted on glass slides with permanent mounting media, and aged independently by three researchers. Annuli were counted toward the anterior apex of the fin ray section to minimize errors in counts (Sokolov and Akimova, 1976, Carlson et al. 1985). Annular distances were measured using an ocular micrometer, and backcalculations were made to assess growth rates using the equation $Li = a + (Lc - a)$

(Si/Sc); where Li = length at age i, Lc = length at capture, Si = distance from focus to annulus i, Sc = distance from focus to edge of fin ray, and a = correction factor = 30.

Seven shovelnose sturgeon were surgically implanted with radio transmitters in a staggered entry design between April and August, 1996 and tracked to study movement patterns. Two fish were implanted with transmitters having external whip antennas that dangled 15 to 20 cm from the belly of the fish. The other five fish received transmitters with an internal loop antenna. Transmitters with whip antennas weighed about 7.5 grams while transmitters with loop antennas weighed about 10 grams.

While implanting the first fish in April, we followed a protocol for implanting Shortnose and Atlantic Sturgeon (Kynard and Kieffer, personal communication) making a small incision on the side of the body between the lower two rows of scutes. Because there was a significant amount of bleeding from the muscle tissue, subsequent transmitters were implanted by making a 3 to 4 cm incision along the ventral mid-line. Three to four sutures were made with braided nylon to close the incision. Fish were placed in an electrolyte, tetracycline, and meracin solution for about 5 minutes to help replace the slime coat and reduce the chance of infection. Meracin and tetracycline tablets (250 mg each) were crushed and dissolved into 38 L of water while salt was added at a concentration of 2.5%.

Attempts were made to locate each fish at least once a week, and occasionally several times in a day. An airboat allowed us to search up to 65 km of river in one day. Upon making a contact with each fish, the time, date, transmitter frequency, and location were recorded. Recaptured fish were examined and scanned for PIT tags to verify their identity. Due to the small sample size, only descriptive statistics were used to analyze radiotelemetry data.

Results

In 1995 and 1996, 494 gill net drifts captured 607 fish, including 127 shovelnose sturgeon. Four others were captured in stationary gill nets in 1995. We also captured a suspected hybrid (*S. platorynchus X S. albus*) at the Elkhorn site on April 20, 1996. One shovelnose sturgeon tagged at Plattsmouth in June, 1996 was recaptured in August, 1996 approximately 1.6 km downstream from the original capture site. No pallid sturgeon were found. Of 21 species captured in drifted gill nets 14 were captured with sturgeon. Table 1 shows the total number, percent of total catch, percent frequency of occurence in gill nets, and percent frequency of occurence with sturgeon for each species. Channel catfish (*Ictalurus punctatus*) were the most abundant species captured in gill net drifts, comprising 23.4% of the total catch. They were captured in 18.6% of drifts and were found with sturgeon over 20% of the time. Shovelnose sturgeon and river carpsucker (*Carpiodes carpio*) were the next most abundant species at 20.9% and 16.1% of the catch, respectively. Sturgeon were captured in 16% of drifts while river carpsucker were captured in 14.4% of drifts and found with sturgeon 18.3% of the time. All other species each comprised less than 10% of the total catch, but goldeye (*Hiodon alosoides*), shortnose gar (*Lepisosteus platystomus*), and blue sucker (*Cycleptus elongatus*) were frequently captured with sturgeon at 30.2%, 33.3%, and 50% of the time, respectively.

The length frequency distribution for shovelnose sturgeon (Figure 2) revealed that 81.5% of fish were between 500 and 625 mm with the most abundant size class being 551 to 575 mm. Figure 3 shows means and ranges for length at each age (at time of capture) based on examination of pectoral fin rays from 139 shovelnose sturgeon. Ages ranged from 3 to 8 years. Over 85% of fish were between age 4 and 6 with mean lengths from about 520 to 600 mm.

The relative abundance of shovelnose sturgeon at each study site changed from month to month. Figure 4 shows CPUA at each site from April through September, 1996.

In April sturgeon were found only at the lower three sites, in May they were collected at all sites except Columbus, and in June and July they were captured at all sites. During April and September CPUA was highest at Louisville and the shape of the CPUA curves were similar for both months. In May and August CPUA was highest at Plattsmouth and the shapes of these curves are similar. In June and July the Elkhorn site had the highest CPUA, and again the shape of these curves are similar.

Table 2 shows the area of river sampled at each site from April through September, 1996. Sampling effort was greatest during June and July at all sites except Plattsmouth, which was greater in May than June. At most sites effort was lower during early spring and late summer. North Bend had the lowest effort among all sites and months during September, with only one hectare sampled. Sampling effort varied greatly by site and month. Despite an increase in effort at Louisville between April and May, CPUA decreased significantly in May. In June and September effort was greatest at Columbus and Fremont, but downstream sites had higher CPUA's. Figure 5 shows CPUA from July through September, 1995. Although the numbers are dramatically different from 1996, the general shape of the CPUA curves from July through September are similar for both years.

For radio telemetry results, each fish will be referred to by the number of its transmitter frequency. Fish #893 weighed 1,090 g and was implanted with a loop antenna transmitter at Louisville, approximately 5 km upstream from Highway 50 on April 13, 1996. This fish was located two days later about 100 meters upstream from the point of release. The only one other contact made with this fish during the life of its transmitter was on August 8, 1996, despite several attempts to locate it. It was found about 26 km downstream from the point of release; only 1.6 km from the mouth of the Platte. A gill net was used to recapture the fish to examine its condition. A concave scar was present from the incision made during surgery, but otherwise the fish appeared healthy. The following day we attempted to locate #893 between the mouth of the Platte and the Elkhorn River without success, and it was never located again.

Fish #863 was a pre-spawn female, weighed 1,180 g, and was implanted with a loop antenna transmitter on June 11, 1996 at the Columbus reach approximately 3 km downstream from Highway 81. She either died or rejected the transmitter within 8 to 11 days. Figure 6 shows the movements of #863 and daily discharge from June 11 through July 12. Daily discharge values that appear on figures for fish implanted near Columbus were taken from the North Bend gaging station. The first night #863 moved downstream about one km where she remained for the next week. Between June 19 and June 22, 1996, #863 moved downstream about 7 km, into a deep channel under a train bridge. Over the next three weeks, the signal did not move from this location despite a significant decrease in discharge and channel depth. On July 12, 1996 we attempted to recapture #863 with gill nets when the channel depth was less than 30 cm, however we did not succeed. We assume that the transmitter was buried in the sand because the signal did not move after deploying gill nets through the entire area several times. Attempts were made to pinpoint and recover the transmitter using a large magnet to deactivate it, however, this was unsuccessful.

Sturgeon #740 weighed 800 g and was implanted with a whip antenna transmitter at Columbus, approximately 2.5 km downstream from Highway 81 on June 25, 1996. This fish was found dead on July 21, 1996, along a shallow sandbar within 2 km of nine other sturgeon, seven sauger, and one flathead catfish. A few days prior to finding these dead fish, a strong rain storm moved through the area causing a significant increase in discharge. Runoff from this storm may have washed something into the water that was responsible for the fish kill. A fish kill was documented in this same stretch of river in June, 1994 due to unknown causes, with at least one sturgeon and several large flathead catfish being found (Nebraska Game and Parks Commission, personal communication).

Photographs were taken of the ten dead sturgeon. Figure 7 shows movements of #740 and daily discharge through time. This fish stayed within a 4 km stretch of river, making small upstream and downstream movements until its death. Although #740 moved upstream during the first week while daily discharge was decreasing, movements during the other three weeks appear to follow the pattern of daily discharge most of the time.

The other four fish were implanted with transmitters at the Elkhorn site; two on July 24, 1996 and two on August 21, 1996. All of these fish were tracked into October, 1996. Fish #760 was implanted on July 24, weighed 895 g, and received a whip antenna transmitter about 5.5 km upstream from the mouth of the Elkhorn River. Figure 8 summarizes daily discharge and the movements of fish #760 through time. Daily discharge values that appear on figures for fish implanted near the Elkhorn River were taken from the Leshara gaging station about 35 km upstream. Fish #760 stayed within a one km stretch of river during the first 11 days and then disappeared. It was located on August 10, 1996 about 15 km upstream. The next contact was made on August 17 about 6 km downstream. Here it stayed within a 1.5 km stretch of river through September 24, 1996. On September 9, we pinpointed and recaptured this fish, took photographs, and released it. Between September 24, 1996 and October 1, 1996 the fish moved about 5 km upstream. It continued moving upstream at least through October 13, 1996 for another 10 km. After October 13, only one contact was made with this fish and no contacts were made with other fish due to a ban on motor boats in this stretch of river from October 15, 1996 through January 15, 1997. We attempted to make contacts from a vehicle, along roads near the river, with no success until October 29. The last contact was made with #760 on October 29, 1996 near Cedar Creek, about 60 km downstream from the October 13 contact point.

Fish #820 weighed 911 g and was implanted on July 24, 1996 with a loop antenna transmitter. It was implanted immediately below the mouth of the Elkhorn River, stayed within a one km stretch of river during the first week, and then disappeared. Figure 9 shows daily discharge and movements of #820 through time. We located the fish about 10 km upstream on August 7, 1996. On August 12, 1996 it was found approximately 26 km downstream, within the Louisville sampling reach. On August 13, 1996 we returned to Louisville to locate the fish, searching downstream to Plattsmouth and upstream to South Bend without making a contact. It was not located again until September 20, 1996 about 9 km upstream from Louisville. Once again this fish disappeared until October 1, 1996 when it was found about 37 km upstream from Louisville, near Two Rivers State Recreation Area. On October 4, 1996 it was located about 2.5 km upstream from the October 1 location. Here it stayed through October 13, 1996, which was the last contact made with this fish.

Fish #800 weighed 620 g and was implanted approximately 1 km upstream from the mouth of the Elkhorn River on August 21, 1996 with a loop antenna transmitter. Figure 10 summarizes daily discharge and movements of #800 through time. This fish moved downstream about 7 km during the first two weeks and then stayed within a 4 km stretch of river, making short upstream and downstream movements through September 24, 1996. The last contact was made with this fish on October 4, 1996 less than one km upstream from its original point of release.

Fish #840 weighed 715 g and was implanted about 3 km upstream from the mouth of the Elkhorn River on August 21, 1996 with a loop antenna transmitter. Figure 11 shows daily discharge and movements of #840 from August 21 through October 4, 1996. It stayed within a two km stretch of river, making small upstream and downstream movements through September 24, 1996. Between September 24, 1996 and October 4, 1996 it moved upstream about 2 km. Last contact was made with this fish on October 4, 1996.

Discussion

Overall, there seems to be a lot of variation between studies for length at each age. Table 3 shows a comparative analysis of length at each age for shovelnose sturgeon from Carlson, et al. (1985), Helms (1974), Carlander (1969), and backcalculated lengths from this study. Carlson et al. (1985) reported shovelnose sturgeon from the Missouri and Mississippi rivers with mean lengths between about 370 mm and 640 mm ranged from age 4 to 14. Helms (1974) reported shovelnose sturgeon from the Mississippi River with fork lengths from 188-716 mm were between age 0 and 12. Carlander (1969) reported shovelnose sturgeon from Lake Oahe, South Dakota had lengths from 213-503 mm with ages from 1 to 10 years. Berg (1981) reported shovelnose sturgeon from the Missouri River in Montana with fork lengths from 533-945 mm ranged from age 8 to 33. Both pallid and shovelnose sturgeon are thought to grow larger in the upper basin than lower portions of the Missouri and Mississippi rivers (Helms 1974, Berg 1981, Keenlyne 1989, Keenlyne et al. 1994). Variations between studies could be due to local differences in growth rates or errors in aging techniques within and between studies. More effort is needed to determine which is the case.

Helms (1974) reported that 40% of age 4 males were mature or developing gonads, while females matured between age 5 and 7. Shovelnose sturgeon from Lake Oahe, South Dakota over 508 mm were considered mature (Carlander, 1969). These are about the same sizes and ages found in abundance during our study, which could reflect the importance of the lower Platte River as a spawning area for shovelnose sturgeon.

Keenlyne et al. (1994) concluded that hybridization may be occurring in over 50% of river reaches within the range of pallid sturgeon and that hybrids may represent a high proportion of remaining sturgeon stocks. We think the largest sturgeon captured (750 mm) was a hybrid because it was only age 9 and had characteristics that were intermediate between pallid and shovelnose sturgeon, as documented by Carlson et. al. (1985). These intermediate characteristics included barbel placement and length, pigmentation, and body size. The inner barbels were shorter and slightly anterior to the outer barbels. The body was lighter in color than most shovelnose sturgeon, but Kallemeyn (1983) reported that color is not always a reliable characteristic for differentiating between pallid and shovelnose sturgeon. The scutes were dull relative to other shovelnose sturgeon that were captured, and finally, this fish was about 10% larger by length and 42% larger by weight than the largest shovelnose sturgeon. No merisitic counts were made but photographs were taken. Comparing the length of our Platte River hybrid at age 9 to the estimated length of Carlson's hybrids at age 9 from the Missouri and Mississippi rivers showed that our fish was about 100 mm larger. In general, the length of shovelnose sturgeon from this study were also about 100 mm larger for each age class compared to lengths reported by Carlson et al. (1985). Differences in size and growth patterns throughout the basin are likely to apply to hybrids as well as the parent species.

CPUA data indicates that sturgeon migrate upstream in the spring as flows increase, and downstream, at least to some degree, later in the year. Upstream movement during spring appears to be a spawning migration. Prespawn females were documented throughout the lower Platte during May and June, 1996. Berg (1981) also documented upstream spawning migrations of shovelnose sturgeon in response to an increase in flows in June. Previous radio telemetry work by Bramblett (1996) and Quist (personal communication) showed that shovelnose sturgeon in the Yellowstone and Kansas rivers respectively, stayed within the tributary throughout the year. They likely remain in the lower Platte throughout the year, as long as suitable flows and depths are available.

Radio transmitters with an internal loop antenna could be located at distances of about 300 m while transmitters with an external whip antenna could be located at greater distances (50-75% farther). Although we did not experience any problems, the obvious disadvantage to using an external whip antenna is that it has the potential to irritate the tissue by vibrating in the current, which could cause transmitter rejection. Fish #760 was equipped with an external whip antenna on July 24 and recaptured 47 days later (September 9) to observe its condition. The tissue immediately surrounding the whip antenna at its point of exit from the body cavity appeared to have developed into a callus. It was a hard nodule that was slightly discolored (pink). There was no swelling and no evidence of surgery, except for the callus and the whip itself. Photographs were taken, and the fish was released again, and tracked through the end of October.

All four sturgeon equipped with transmitters near the Elkhorn River moved upstream following an increase in discharge in late September and early October. Given that this occurred during fall when water temperatures and day lengths were decreasing, an increase in discharge appears to be the most important factor triggering upstream movement, regardless of the time of year. Shovelnose sturgeon appear to move upstream and downstream in response to increasing and decreasing discharge, respectively. Five out of six fish that were successfully tracked for over a month (#740, #820, #760, #800, and #840) showed a positive relationship between movement and discharge. Fish #863 died or rejected the transmitter shortly after being implanted, therefore only downstream movement was documented for this fish, and no relationship could be observed for #893 since only two contacts were made.

In most cases sturgeon remained within a relatively narrow stretch of river, close to the point of release, however some fish showed the ability to move long distances, both upstream and downstream. Bramblett (1996) also reported the ability of pallid and shovelnose sturgeon to make rapid upstream and downstream movements. The greatest distance between two contact points for one fish (#760) was about 60 km. Hurley et al. (1987) showed that shovelnose sturgeon in the upper Mississippi were generally sedentary but did move up to 11.7 km in a day. Helms (1974) also found little movement of shovelnose sturgeon in the upper Mississippi River, with mean distances moved from the capture site of 2.6 and 0.8 km upstream and downstream respectively. Bramblett (1996) showed the range of shovelnose sturgeon was greatest during summer months with distances moved up to 250 km. Tews (1994) reported movements of over 300 km in the Missouri and Yellowstone rivers in Montana.

Bramblett (1996) also found a positive correlation between movements and daily discharge for both pallid and shovelnose sturgeon in the Yellowstone and upper Missouri rivers, but found negative correlation's in the lower Missouri. If a relationship between movement and daily discharge can be verified in other areas, this could be an enormous advantage for locating transmitter fish that have disappeared. This information could also have great utility in guiding management recommendations regarding the timing and intensity of flows.

Chapter 2: Habitat use and food habits of shovelnose sturgeon, *Scaphyrhynchus platorynchus*, in the lower Platte River, Nebraska

Introduction

Development of habitat suitability criteria for riverine fishes is an important challenge for fisheries biologists. Anthropogenic habitat modifications throughout the Missouri and Mississippi River basin have often been implicated for having negative effects on native wildlife, fish, and invertebrate communities (Hesse 1987, Keenlyne 1989). Hesse (1987) reported that dams and channelization have caused reductions in allochthonous carbon inputs and community structure may now depend more on autochthonous sources of carbon. Dams are thought to impact pallid and shovelnose sturgeon by blocking movements to spawning and feeding areas. These impoundments along with channelization have destroyed spawning habitats, altered water temperatures, turbidities, flow regimes, and reduced the food supply (Keenlyne 1989).

Identification of habitat use and food habits of river sturgeons throughout their range are two research priorities listed in the recovery plan for pallid sturgeon (Dryer and Sandvol, 1993). Peters, et. al. 1989 and Holland and Peters 1994 proposed habitat suitability criteria for 18 groups of invertebrates and 29 species of fish in the lower Platte River, Nebraska, but none have been established for shovelnose sturgeon. The objectives of this research were to document habitat use, develop habitat suitability criteria, and identify food habits of shovelnose sturgeon populations in the lower Platte River, Nebraska.

Methods

Fish were captured at six sampling reaches in the lower 160 km of the Platte River (Figure 1) using gill nets drifted with the current. Within each sampling reach, tributary mouths and river channels were sampled from July through October, 1995, and April through September, 1996. Nets were either 15.2 or 30.5 m long, and in 1995 they were made up of four panels of alternating 2.5 and 5.1 cm monofiliment mesh. In 1996, four mesh sizes were used, including 1.3, 2.5, 5.1 and 7.6 cm bar mesh. Because the mouths of most tributaries were too small to sample with gill nets, we drifted nets directly below the confluence of these tributaries. Only the Loup River at Columbus, the Elkhorn River at the Elkhorn site, and the mouth of the Platte at Plattsmouth were large enough to drift nets within the tributary mouth. We defined tributary habitats as being 300 m within the mouth to 300 m above and below the confluence.

Habitat including water depth, mean column velocity, bottom velocity, substrate, cover, dissolved oxygen, water temperature, and turbidity were measured in each sample area regardless of whether or not fish were captured. Mean column velocity was measured at 0.6 X depth and bottom velocity was measured 12 cm above the substrate using a pygmy current meter. Cover was defined as channels in which the gill net hung up on debris during a drift. Habitats were measured at the beginning, middle, and end of each drift at the point in the channel where the middle of the net was sampling. Dissolved oxygen, water temperature, and turbidity were measured only at the mid-point of each drift.

To study movement patterns and habitat use, seven sturgeon were implanted with radio transmitters in a staggered entry design between April and August, 1996. We attempted to locate each fish from a minimum of once each week to several times in a day. At each contact, we determined the exact location of the fish by pinpointing the strongest signal from several angles. Once the location was determined we recorded the time, date, GPS location, transmitter frequency, and water temperature. Depth, mean column velocity, bottom velocity, substrate, and cover were measured at 5 points within the diameter of the circle (center, 5 m upstream, 5 m downstream, 5 m left, and 5 m right). Cover was defined as present or absent.

Analysis of variance (ANOVA) was used (Steel and Torrie 1980) to determine if availability and use of depth, mean column velocity, bottom velocity, water temperature, and turbidity by sturgeon differed by site and month using a 0.05 significance level. To test for differences in habitat use, parameters were weighted by the number of sturgeon captured in a particular location. We also used ANOVA to test for differences in depths, mean column velocities, and bottom velocities used by each transmitter fish, and between all fish captured in gill nets and all transmitter fish. Because the data were sparse, Fisher's exact test (Steel and Torrie 1980) was used to assess whether proportions of sturgeon captured were significantly different for tributary vs. river channels and cover vs. open channels. Habitat preference and suitability were determined for shovelnose sturgeon for each habitat parameter using methods described by Peters et al. (1989). Only fish captured in gill nets were included in preference and suitability models since demonstrating preference for habitat parameters such as depth or velocity requires knowledge of the availability of those parameters at the same time the use is documented (Bramblett 1996).

Stomach contents were flushed from 84 sturgeon between September, 1995 and September, 1996 using pulsed gastric lavage, and preserved in 10% formalin. In the laboratory, food items were sorted, identified to family using Merritt and Cummins (1984), and transferred to 70% ethanol. The percent of material too digested for identification was estimated visually, and food habit analysis was reported numerically and as a percentage for the numbers and frequency of occurrence of different food items found.

Results

In 1995 and 1996, 494 gill net drifts caught 607 fish, including 127 shovelnose sturgeon and one suspected hybrid (*S. platorynchus X S. albus*). Figure 12 shows percent availability and use of depths by shovelnose sturgeon. Depths most frequently sampled ranged from 31-60 cm while sturgeon were most frequently captured between 61 and 90 cm. Sturgeon were captured at depths up to 240 cm. There was a significant difference in habitat availability for depth by site (p=.014) and month (p=.0001) during 1996 but only month was significant during 1995 (p=.001). Figure 13 shows the range and means for depths sampled in the lower Platte River at each site from April through September, 1996. Mean depths at downstream sites were generally deeper than upstream sites, and differences by month appear to be related to discharge. Figure 14 shows monthly means for daily discharge in the lower Platte River from April through September, 1996. There was no difference in depths used by sturgeon at capture locations by site (p=.85) or month (p=.75) during 1995, nor by site (p=.19) nor month (p=.09) during 1996. There was no difference in depths used amoung transmitter fish (p=.48) nor between transmitter fish and fish captured in gill nets (p=.63). Figure 15 shows depth preference and suitability for shovelnose sturgeon in the lower Platte River. Both preference and suitability were greatest for depths between 151 and 180 cm, followed by depths between 181 and 210 cm.

Figure 16 shows mean column velocity percent availability and use by shovelnose sturgeon. Mean column velocities most frequently sampled were from 61-75 cm/sec and those at which sturgeon were most frequently captured were also from 61-75 cm/sec. The second most frequently sampled mean column velocities were from 76-90 cm/sec while the second most frequently observed velocities with sturgeon were from 46-60 cm/sec. There was a significant difference in habitat availability for mean column velocity by site (p=.047) and month (p=.040) during 1995 and by site (p=.0009) and month (p=.001) during 1996. Figure 17 shows the range and means for mean column velocities sampled at each site from April through September, 1996. During most months, mean column velocity means were greater at upstream sites than downstream sites, but there was a lot of variability. During June the range of mean column velocities sampled was greatest for all sites. There was no significant difference in mean column velocities used by sturgeon at capture locations by site (p=.73) or month (p=.58) during 1995 nor by site (p=.17) nor month (p=.98) during 1996. There was no difference in mean column velocities used amoung transmitter fish (p=.27) nor between transmitter fish and fish captured in gill nets (p=.42). Figure 18 shows shovelnose sturgeon habitat preference and suitability for mean column velocity. Both preference and suitability were greatest for mean column velocities between 46 and 60 cm/sec, but there was a wide range of suitable and preferred mean column velocities.

Figure 19 shows bottom velocity percent availability and use by sturgeon. Bottom velocities most frequently sampled were from 46-60 cm/sec while those at which sturgeon were most frequently observed were from 31-45 cm/sec. There was a significant difference in habitat availability for bottom velocity by site (p=.01) and month (p=.001) during 1996 but neither site (p=.11) nor month (p=.69) were significant during 1995. Figure 20 shows the range and means for bottom velocities sampled at each site from April through September, 1996. Mean bottom velocities were generally greater at upstream sites than downstream sites, and during June, means and ranges were generally greater than during other months. There was no significant difference in bottom velocities used by sturgeon at capture locations by site (p=.49) or month (p=.58) during 1995 nor by site (p=.15) nor month (p=.70) during 1996. There was no difference in bottom velocities used among transmitter fish (p=.54) nor between transmitter fish and fish captured in gill nets (p=.28). Figure 21 shows shovelnose sturgeon habitat preference and suitability for bottom velocity. Both preference and suitability were greatest for bottom velocities between 16 and 30 cm/sec., followed by bottom velocities from 31 to 45 cm/sec.

Figure 22 shows percent availability and use of substrates by sturgeon from April through September, 1996. Sand was the dominant substrate available during all months, but during summer months availability of silt and gravel increased. Sturgeon were most frequently documented over sand during most months, but during May and July sturgeon were found over silt at high frequencies relative to its availability. Figure 23 shows shovelnose sturgeon habitat preference and suitability for substrates. Both preference and suitability were greatest for silt, followed by gravel, and then sand.

Figure 24 shows percent availability and use by sturgeon for cover and open channels from April through September, 1996. Channels with cover and open channels were sampled in similar proportions during most months, but during August channels with cover were more frequently sampled, and during September open channels were more frequently sampled. Sturgeon were documented in both habitats in similar proportions to their availability each month. Across all months there was no significant difference in the proportions of sturgeon captured in cover vs. open channels ($p=.83$). Figure 25 shows shovelnose sturgeon habitat preference and suitability for cover and open channels. Open channels were highest for both preference and suitability, but channels with cover were nearly equally preferred and suitable.

Figure 26 shows percent availability and use by sturgeon for tributary and river channel habitats from April through September, 1996. During all months channel habitats were sampled more frequently than tributaries, and sturgeon were documented in each habitat in similar proportions to their availability. Across all months there was no significant difference in proportions of sturgeon captured in tributary vs. river channel habitats ($p=.83$). Figure 27 shows shovelnose sturgeon habitat preference and suitability for tributary and river channel habitats. Channels were greater for both preference and suitability, but tributaries were nearly equally preferred and suitable.

Figure 28 shows the range of water temperatures recorded in the lower Platte each month. Availability and use of water temperatures by sturgeon were significantly different by month in 1995 ($p=.0001$) and 1996 ($p=.0001$). Temperature was not significant by site during 1995 for availability ($p=.12$) or use ($p=.09$), nor for availability ($p=.85$) or use ($p=.80$) during 1996 . During 1995 turbidity was significantly different by site ($p=.004$) and month ($p=.0001$) for availability and by site ($p=.02$) and month ($p=.0001$) for use. During 1996 turbidity was not significantly different by site for availability ($p=.90$) nor use ($p=.99$), but month was significant for availability ($p=.01$) and use ($p=.03$). Sturgeon were documented throughout the range of water temperatures and turbidities that were recorded in the lower Platte River. Temperatures ranged from 5.9 ^{o}C in October, 1995, to 30.9 ^{o}C in July, 1996, and turbidities ranged from 15 to greater than 500 NTU.

Eighty-four sturgeon were sampled for food habits, including five fish in September, 1995, one in October, 1995, and seventy eight between April and September, 1996. Aquatic invertebrates made up the entire diet of shovelnose sturgeon sampled. Table 4 shows frequency of occurrence, numbers, and numerical percentages for aquatic insect orders and families found. Six fish had empty stomachs (one in September, 1995, one in May, July, and August, 1996, and two in June, 1996). The order Diptera was highest in percent frequency of occurence and total organisms, accounting for over 97% of all organisms found, and nearly all of those were chironomids. Other families found in the order Diptera included Culicidae, Ceratopogonidae, Tipulidae, Ephydridae, Dolichopodidae, Tabanidae, Chaoboridae, and Simulidae. Ephemeroptera and Trichoptera accounted for 1.1 and 1.2% of total organisms, respectively, but both were relatively high in frequency of occurrence at 34.5 and 27.4%, respectively. Families within Ephemeroptera included Caenidae, Baetidae, Oligoneuridae, Heptageniidae, Leptophlebiidae, and Tricorythidae. Within Trichoptera only hydropsychids were found.

Other groups of invertebrates that were found included Oligochaeta, Gastropoda, Coleoptera, Hemiptera, and Odonata.

Table 5 shows percent by numbers and frequency of occurrence for aquatic insect orders and families found each month, from April through September, 1996. In April, no identifiable organisms were found in stomach samples, but digested material was found in all seven fish. Chironomids were highest in percent by numbers from May through September, but were equal in percent frequency of occurence during May with culicids, ephemeropterans, and trichopterans. The mean number of chironomids found per fish from April through September were 0, 47, 141, 1066, 752, and 122, for each month, respectively. Culicids and ephemeropterans were represented in stomach samples from May through September. Culicids were highest in percent frequency of occurence in August at 50%, while ephemeropterans were highest in percent frequency of occurence during July, when caenids, baetids, and oligoneurids were found in 47.4, 31.6, and 15.8% of samples, respectively. Hydropsychids were also a consistent part of the diet of shovelnose sturgeon from May through September, with the exception of June, when no hydropsychids were found.

Figure 29 shows the percent of fish with 100% digested material and mean percent of digested material per fish from April through September, 1996. In April no identifiable organisms were found and all seven fish had only digested material. In May, nearly 60% of fish sampled had 100% digested material with a mean of 93% per fish. In June only about 29% of fish had 100% digested material with a mean of 78% per fish. From July through September no fish were found with 100% digested material and the mean percent of digested material per fish was 48%, 8%, and 8% for each month, respectively.

Discussion

We concentrated our sampling efforts in river channel habitats that were likely to hold sturgeon at each site each month. These habitats were generally deeper than the most abundant habitat in terms of availability in the Platte River. Peters et al. (1989) showed that over 90% of the Platte River is less than 60 cm deep with a mean depth of only 26 cm. Because we were biased toward sampling deeper habitats we found a larger proportion of available depths that were greater than 60 cm compared to availability reported by Peters et al. (1989). Percent availability of habitat intervals for each habitat parameter were determined by dividing observations for an interval by the sum of all interval values present within a microhabitat variable, and multiplying by 100 (Peters et al. 1989). Percent availability of habitat intervals from this study reflect availability within river channel habitats, not the entire lower Platte River. Percent use by sturgeon of habitat intervals for each habitat parameter were determined by dividing the observations of sturgeon in a habitat interval by the total number of times the habitat variable was sampled, and multiplying by 100 (Peters et al. 1989).

Habitat preference was determined by dividing percent use of a habitat interval by percent availability of that interval, then dividing each of these values by the sum of all values recorded for the habitat variable (Peters et al. 1989). Suitability was determined by giving the interval with the greatest preference a value of one, and all other intervals were relative. Only about 2% of available depths from this study were between 151 and 180 cm, which was the category of depth with the highest shovelnose sturgeon preference and suitability. This range of depths does not even appear in a comparative graph of availability of depths in the lower Platte River (Peters et al. 1989).

Velocity measurements at locations where shovelnose sturgeon were captured in the lower Platte River were similar to values reported in other studies. Latka (1994) found that CPUE was highest when bottom velocities were 20 to 70 cm/sec and mean column velocities were 30 to 100 cm/sec., and he found no difference in velocities used by shovelnose sturgeon in the channelized Missouri River by season (navigation vs. nonnavigation). Bramblett (1996) reported shovelnose sturgeon used bottom velocities from 2 to 151 cm/sec. and mean column velocities from 2 to 181 cm/sec. Curtis (1990) reported bottom velocities at sturgeon locations were most commonly between 20 and 45 cm/sec. Hurley et al. (1987) reported the highest percent frequency of velocities used by shovelnose sturgeon for surface velocity were 55 to 65 cm/sec and those for bottom velocity were 25 to 35 cm/sec. Nearly 20% of available mean column velocities and 15% of bottom velocities from our study were in the highest shovelnose sturgeon preference and suitability categories (46-60 cm/sec. and 16-30 cm/sec, respectively). Peters et al. (1989) found that over 40% of available mean column velocities were between 40 and 60 cm/sec which suggests that the lower Platte River has a high percentage of mean column velocities which are preferred and/or suitable for shovelnose sturgeon.

Peters et al. (1989) found that sand comprised over 80% of available substrates in the lower Platte River and also documented an increase in the availability of silt and gravel during summer. We found that sturgeon frequently used silt during May and July which could relate to an increase in feeding activity levels before and after the spawn, because we suspect most sturgeon spawned during May and June (Chapter 3). Peters et al. (1989) reported that chironomids showed a greater preference for silt over sand or gravel substrates. However, the mean number of chironimids per fish does not support this theory for May, and during June we did not observe a dramatic increase in the use of gravel for spawning.

Channels with cover as we defined them were not what most people would consider to be channels with in-stream cover, because even a small stick within the channel could cause gill nets to become entangled. Although we did not intentionally drift nets into cover, we thought it was important to test for differences between drifts in which nets became entangled and drifts in which they did not. Over time we became more proficient at releasing gill nets from cover before they actually stopped drifting, so this may have helped to prevent differences from being observed.

Holland and Peters (1989) described a persistent difference in conductivity between north and south banks of the lower Platte River for up to 72 km below the confluence of the Platte and the Loup River Power Canal near Columbus. This suggests that chemical differences originating from tributaries may persist at distances greater than 300 m below the tributary mouth, therefore the use of "tributaries" by sturgeon could actually be greater than we reported.

Latka (1994) found that shovelnose sturgeon avoided the main channel in channelized sections of the Missouri River, and congregated near tributary mouths during the navigation (high flow) season, but were equally distributed in main channels and tributary mouths during the non-navigation season. He suggested that tributaries and wing dams serve as important seasonal habitats during high flows in channelized sections of the Missouri River. Other researchers have also reported shovelnose sturgeon using structures such as wing dikes and log jams for velocity refuges during high flows (Hurley et al. 1987, Mike Quist, Kansas State University, personal communication). In our study, sturgeon were often found using the channel-pool interface below sandbars. These areas were characterized by a visible break-line on the surface of the water, which aided in identifying habitats likely to hold sturgeon. Latka (1994) reported habitats used by shovelnose sturgeon as having a sandbar-pool topography, and Schmulbach et al. (1975) and Moos (1978) reported frequent catches of shovelnose sturgeon below sandbars. Hurley et al. (1987) suggested that submerged structures such as wing dams in the upper Mississippi River may provide habitats that are similar to sandbar habitats of unchannelized areas in the Missouri River. In unchannelized sections of the Missouri River and its major tributaries, the channel-pool interface below sandbars probably serves as an important velocity refuge habitat as well as a deposition area for silt and food organisms.

Aquatic invertebrates accounted for all organisms found in the stomachs of sturgeon sampled from the lower Platte River, and invertebrates have consistently been documented as making up the majority of their diet elsewhere (Held 1969, Pflieger, 1975, Modde and Schmulbach 1977, Carlson et al., 1985). These studies also documented the importance of dipterans in the diet of shovelnose sturgeon by their frequency of occurrence. Held (1969) reported dipterans were found in over 97% of samples, Modde and Schmulbach (1977) reported chironomids were found in 95.9-100% of samples, and Carlson et al. (1985) reported dipterans were found in 81.2% of samples.

We did not experience problems obtaining stomach samples from most sturgeon using pulsed gastric lavage, although we were unable to obtain samples from six fish. Occasionally sturgeon would regurgitate when turned upside-down, prior to performing PGL, and some fish had live chironomids in their stomachs. Sturgeon stomachs are modified into grinding organs (Held 1969) and they have spiral valve intestines (auger-like) which maximize the surface area for digestion (Moyle and Cech 1988). We found that shallow to moderate penetration of PGL tubing into the esophagus with small back and forth movements facilitated removal of food organisms. Held (1969) eviscerated shovelnose sturgeon from the Missouri River and reported their esophagus's were often distended with food while stomachs were nearly empty. We feel that PGL is a satisfactory method for obtaining stomach contents from shovelnose sturgeon without sacrificing the fish.

Chapter 3: Larval fish collections in the lower Platte River, Nebraska

Introduction

In 1990 the U.S. Fish and Wildlife Service listed pallid sturgeon *Scaphyrhynchus albus* on the Federal Registry for Endangered Species, and has since developed a recovery plan, with one research objective to document reproduction and spawning habitats of pallid sturgeon, because no eggs or larvae have ever been documented in the wild (Dryer and Sandvol 1993). Shovelnose sturgeon have served as the closest model for determining spawning requirements for pallid sturgeon (Dryer and Sandvol 1993). Shovelnose sturgeon spawn within main channels of large turbid rivers over rocky or gravelly substrates (Pfleiger, 1975) when water temperatures are between 14 and 21 °C (Holland and Hustin 1983). These closely related species (Phelps and Allendorf 1983) have been known to hybridize (Carlson et al. 1985, Dryer and Sandvol 1993), which suggests they may indeed have similar spawning habitat requirements. It has also been suggested that hybridization may be a recent event resulting from reductions in habitat diversity and environmental degradation throughout much of their range, which is thought to have inhibited reproductive isolating mechanisms and forced both species to share the remaining suitable spawning habitats (Carlson et al. 1985, Dryer and Sandvol, 1993).

Major tributaries of the Missouri and Mississippi rivers may hold some of the best opportunities for documenting reproduction of rare river fishes such as pallid sturgeon since these areas are thought to serve as important feeding and nursery areas for many large-river fishes (Dryer and Sandvol 1993). "They are typically less degraded, have higher habitat diversity, and some still exhibit a natural configuration of sandbars, side channels, and varied depths" (Dryer and Sandvol, 1993). Several tributaries including the confluence of the Platte and Missouri rivers in Nebraska, and adjoining stretches of river, have been established as recovery priority management areas due to the frequency of pallid sturgeon reports around these areas (Dryer and Sandvol, 1993). The lower Platte River provided an excellent opportunity to sample eggs and larval fish while conducting field investigations on shovelnose sturgeon populations. The primary objective of this research was to determine if the Platte River is acting as a spawning area for sturgeon by sampling and identifying eggs and larval fish in the drift.

Methods

Larval drift nets were used to capture ichthyoplankton at six sites in the lower 160 km of the Platte River from May through July, 1996 (Figure 1). Nets were 0.5 m in diameter at the mouth, 2 m long, conical in shape, and made with 150 micron mesh. The mouth of the net was attached near the bottom of a rectangular steel frame that was about 1.5 m tall and 0.6 m wide. A detachable bottle at the back of the net allowed for easy transfer of material into sample jars. Nets were held facing into the current along the bottom in river channels for five minutes at a time. Water velocity was measured at the mouth of the net using a pygmy current meter to determine the volume of water sampled. All samples were labeled and preserved in 10% formalin during field collections.

In the laboratory, drift net samples were stained with Beibrich scarlet and thoroughly examined for eggs and larval fish. All ichthyoplankton were removed and transferred into 70% ethanol. Larval fish were identified to family using Auer (1982) and eggs were identified to family using descriptions given by May and Gasaway (1967), Wallus and Voigtlander (1979), Holland and Huston (1983) and Auer (1982). We also used a family pictoral key (Holland and Huston 1983) and cross referenced specimens with known spawning temperatures and timing to ensure proper identification. All ichthyoplankton were classified as being in one of six developmental stages (modified from Auer 1982).

Egg: From fertilization to hatch.

Pro-yolk-sac larva: Immediately during and following the hatch. Larva looks like an egg with a tail. Eyes not pigmented and larva may bear external membrane.

Yolk-sac larva: From pigmentation of eyes to absorption of yolk sac.

Larva: From absorption of yolk-sac to absorption of finfold and development of fin rays

Juvenile: From development of fin rays to sexual maturity. Look like a small adult.

Adult: Sexually mature.

Results

Between May and July, 1996 we filtered 3,891 cubic meters of river water from 126 drift net samples. Of these, 119 (94%) contained ichthyoplankton. A total of nine families at various stages of development were represented in the drift. Table 6 shows frequency of occurrence, numbers, and numerical percentages for each life stage found within each family. Cyprinidae and Sciaenidae together comprised over 97% of the total ichthyoplankton. Cyprinids made up 78.5% of the total ichthyoplankton and were found in over 83% of samples. Sciaenids were only 19.2% by number, but were found in 53.2% of samples.

Cyprinid yolk-sac larvae were the most frequently observed organisms, accounting for 24% of ichthyoplankton and they were found in 75.4% of samples. Cyprinid pro-yolk-sac larvae were the second most frequently observed but were the most abundant in terms of total organisms. They were found in 64.3% of samples and accounted for 45.1% of ichthyoplankton. Eggs in the family Sciaenidae were the third most frequently observed organism. They were found in 44.4% of samples and accounted for 16.8% of ichthyoplankton. Life stages of Acipenseridae, Clupeidae, Catostomidae, Ictaluridae, Atherinidae, Centrarchidae, and Percidae each comprised less than 2% of ichthyoplankton and occurred in less than 20% of samples.

Table 7 shows the total number of each life stage found within each family from May through July, 1996. One acipenserid yolk-sac larva was found on June 10, 1996, at the Fremont site. Clupeids were found during June and July, with 5 larvae found in June and 2 yolk sac larvae and 2 larvae found in July. Cyprinids were found during all three months with the largest number per unit volume during July. Cyprinid pro-yolk-sac larvae were the most abundant life stage during June and July, but eggs and yolk-sac larvae were more abundant in May. Catostomid yolk-sac larvae were most abundant during June while yolk-sac larvae and juveniles were equal in number during July. Three ictalurid juveniles were found in July and two Atherinid larvae were found in June. One centrarchid yolk-sac larva and one larva were found during June and nine juveniles were found in July. One percid pro-yolk-sac larva and one larva were found in May.

We suspect most shovelnose sturgeon spawned during May and June because prespawn females were captured in gill nets throughout the lower Platte River and water temperatures (figure 28) were within the range of spawning temperatures reported for shovelnose sturgeon during both months. In July only one sturgeon captured at Fremont appeared to still be bearing eggs. We attempted to express eggs and milt from all sturgeon captured during May and June, with no success.

Discussion

Most authors do not differentiate between pro-yolk-sac larvae and yolk-sac larvae, but we separated them because we felt that there may be differences in the susceptibility of these two "life stages" to being captured in the drift for some groups. Pro-yolk-sac larvae were found only in the families Percidae, Sciaenidae, and Cyprinidae, and they were found in nearly equal numbers to yolk-sac larvae for percids and sciaenids. The number of pro-yolk-sac larvae was greater than yolk-sac larvae during June and July for cyprinids, but this could simply be due to differences in their abundance rather than susceptibility to drift nets. Cyprinidae was consistently the most abundant family found, and probably included several species. Hergenrader et al. (1982) reported cyprinids (including carp) comprised 40% of larval fish collected at the mouth of the Platte, while catostomids comprised 46.5%.

Out of 160 species that have been described within the family Sciaenidae, only one species, freshwater drum *Aplodinotus grunniens*, is found in North American fresh waters (Holland and Huston 1983). Drum spawn in open water and have nonadhesive eggs (May and Gasaway 1967, Wallus and Voigtlander 1979, Auer 1982, and Holland and Huston 1983) which makes them highly susceptible to being captured in the drift. Holland and Huston (1983) reported freshwater drum eggs accounted for 83% of all eggs found near Quad Cities Station in the upper Mississippi River during 1976 and 98% in 1978. Hergenrader et al. (1982) reported larval drum comprised from 33.8 to 87.0% of all larval fish taxa collected from the Missouri River adjacent to Nebraska between 1974 and 1977.

The sturgeon yolk-sac larva found on June 10, 1996, at the Fremont site was 8.0 mm in length. Larval pallid and shovelnose sturgeon both hatch at lengths of 8-9 mm and look almost identical (Snyder, 1994). Snyder (1994) provided a diagnostic key for differentiating between them, but unfortunately this key is not useful for recently hatched specimens less than 10 mm in length. We are assuming this fish is a shovelnose sturgeon.

Larval sturgeon are rarely found anywhere within the range of pallid sturgeon which suggests low reproductive rates or failure of standard sampling gear to capture them (Dryer and Sandvol 1993). Eggs of sturgeon adhere to objects after spawned (Holland and Huston 1983) and larvae become buoyant or active immediately following the hatch (Moyle and Cech 1988). Helms (1974) attempted to collect larval sturgeon in the Mississippi River, with no success. Cada (1977) reported one larval sturgeon from the Missouri River near Fort Calhoun Nuclear Station. Hesse and Mestl filtered 519,400 cubic meters of river water from the Missouri River adjacent to Nebraska, between 1983 and 1991 and found only two sturgeon larvae (Hesse personal communication). No sturgeon eggs or larvae were documented in the Platte River prior to our collection (Richard Holland, Nebraska Game and Parks Commission, personal communication). Considering we found one sturgeon larva in the lower Platte River after filtering only 3,891 cubic meters of water during one summer, this should generate interest in future efforts to document sturgeon reproduction in the lower Platte River.

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Table 1. Total number, percent of total catch, percent frequency of occurence, and percent frequency of occurence with sturgeon for all species captured in drifted gill nets in the lower Platte River during 1995 and1996.

Common name	Number captured	Percent of total catch	Percent frequency	Percent freq. with sturgeon
Shovelnose sturgeon	127	20.9	16.0	N/A
Suspected hybrid sturgeon	1	<1	<1	N/A
Longnose gar	33	5.4	5.5	25.9
Shortnose gar	23	3.8	4.3	33.3
Gizzard shad	21	3.5	2.6	15.4
Goldeye	53	8.7	8.7	30.2
Common carp	27	4.4	4.7	13.0
Grass carp	2	<1	<1	50.0
Golden shiner	1	<1	<1	0
Flathead chub	11	1.8	1.6	0
Silver chub	28	4.6	3.4	0
Red shiner	1	<1	<1	100
Blue sucker	8	1.3	1.6	50.0
Smallmouth buffalo	1	<1	<1	0
River carpsucker	98	16.1	14.4	18.3
Shorthead redhorse	4	<1	<1	33.3
Channel catfish	142	23.4	18.6	20.7
Flathead catfish	2	<1	<1	50.0
White bass	2	<1	<1	0
Walleye	4	<1	<1	50.0
Sauger	7	1.2	1.2	0
Freshwater drum	11	1.8	2.2	36.4

Table 2. Sampling effort (number of hectares of river sampled with drifted gill nets) at each site from April through September, 1996.

	April	May	June	July	August	September
Columbus	3.2	4.4	18.0	10.4	7.1	5.2
North Bend	2.3	4.7	12.0	10.5	5.3	1.0
Fremont	6.4	2.8	19.0	10.1	6.2	6.0
Elkhorn	3.0	9.5	11.5	11.1	6.4	1.8
Louisville	7.2	11.8	13.7	12.3	6.2	1.7
Plattsmouth	2.6	10.4	10.2	13.2	4.4	2.0

Table 3. Comparison of length (mm) at each age for shovelnose sturgeon from the Missouri, Mississippi, and Platte rivers, and Lake Oahe, SD.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Missouri and Mississippi rivers (Carlson et al. 1985)	-	-	-	370	385	470	490	530	590	560	580	600	640	640
Lake Oahe, SD. (Carlander 1969)	213	274	325	366	399	437	470	483	457	503	-	-	-	-
Mississippi River (Helms 1974)	211	328	424	495	554	592	625	650	678	701	709	696	-	-
Platte River (Current study)	258	339	404	457	491	547	580	590	-	-	-	-	-	-

Table 4. Frequency of occurence, numbers, and numerical percentages of food items taken from the stomachs of 84 shovelnose sturgeon captured in the lower Platte River from September, 1995 through September, 1996.

	Frequency		Numbers	
STOMACH CONTENTS	NUMBER	PERCENT	NUMBER	PERCENT
EMPTY	6	7.1	N/A	N/A
DIPTERA	58	69.0	33082	97.7
Chironomidae	53	63.1	32902	97.1
Culicidae	20	23.8	118	<1
Others	5	5.9	62	<1
EPHEMEROPTERA	29	34.5	383	1.1
Caenidae	18	21.4	137	<1
Baetidae	12	14.3	121	<1
Oligoneuridae	5	5.9	64	<1
Unidentifiable	7	8.3	35	<1
Others	7	8.3	26	<1
TRICHOPTERA	23	27.4	394	1.2
Hydropsychidae	23	27.4	394	1.2
OTHER GROUPS	8	9.5	11	<1

Table 5. Percent by numbers and frequency of occurence of food items found in the stomachs of 78 shovelnose sturgeon between April and September, 1996.

	Apr n=7		May n=17		Jun n=21		Jul n=19		Aug n=8		Sep n=6	
Stomach Contents	Percent Numbers	Percent Freq.	Percent Numbers	Percent Freq.	Percent Numbers	Percent Freq.	Percent Numbers	Percent Freq.	Percent Numbers	Percent Freq.	Percent Numbers	Percent Freq.
Diptera	0	0	48.0	29.4	98.5	71.4	97.2	94.7	99.3	87.5	98.8	100
Chiron-omidae	0	0	29.6	17.6	97.9	66.7	96.9	94.7	98.9	87.5	98.4	100
Culicidae	0	0	11.1	17.6	<1	14.3	3.2	42.1	<1	50.0	<1	33.3
Others	0	0	7.4	5.9	0	0	<1	5.3	<1	12.5	0	0
Ephem-eroptera	0	0	14.8	17.6	1.5	23.8	1.1	57.9	<1	37.5	<1	16.7
Caenidae	0	0	0	0	1.2	19.0	<1	47.4	<1	37.5	0	0
Baetidae	0	0	0	0	<1	4.8	<1	31.6	<1	37.5	<1	16.7
Oligoneu-ridae	0	0	0	0	0	0	<1	15.8	<1	12.5	0	0
Unidentif-iable	0	0	11.1	17.6	0	0	0	0	0	0	0	0
Others	0	0	0	5.9	0	0	<1	10.5	0	0	0	0
Trichop-tera	0	0	14.8	17.6	0	0	1.7	37.5	<1	37.5	<1	33.3
Hydrops-ychidae	0	0	14.8	17.6	0	0	1.7	37.5	<1	37.5	<1	33.3
Other Groups	0	0	11.1	11.8	<1	4.8	<1	5.3	0	0	0	0

Table 6. Frequency of occurence, numbers, and numerical percentage for each of six life stages of fish captured in larval drift nets in the lower Platte River, Nebraska, from May through July, 1996.

	Frequency		Numbers	
Family / Stage	Number	Percent	Number	Percent
ACIPENSERID.	1	<1	1	<1
YS Larvae	1	<1	1	<1
CLUPEIDAE	6	4.8	9	<1
YS Larv	2	1.6	2	<1
Larvae	4	3.1	7	<1
CYPRINIDAE	105	83.3	2651	78.5
Egg	41	32.5	136	4.0
Prolarvae	81	64.3	1529	45.1
YS Larvae	95	75.4	811	24.0
Larvae	20	15.9	64	1.8
Juvinile	14	11.1	105	3.1
Adult	6	4.8	6	<1
CATOSTOMID.	23	18.3	61	1.8
YS Larvae	18	14.3	53	1.6
Larvae	2	1.6	2	<1
Juvinile	5	4.0	6	<1
ICTALURIDAE	2	1.6	3	<1
Juvinile	2	1.6	3	<1
ATHERINIDAE	1	<1	2	<1
Larvae	1	<1	2	<1
CENTRARCH.	8	6.3	11	<1
YS Larvae	1	<1	1	<1
Larvae	1	<1	1	<1
Juvinile	6	4.8	9	<1
PERCIDAE	2	1.6	2	<1
Prolarvae	1	<1	1	<1
Larvae	1	<1	1	<1
SCIAENIDAE	67	53.2	648	19.2
Egg	56	44.4	569	16.8
Prolarvae	12	9.5	38	1.1
YS Larvae	15	11.9	39	1.1
Juvinile	2	1.6	2	<1

Table 7. Total number of each ichthyoplankton life stage found in each family from May through July, 1996 in the lower Platte River, Nebraska.

	n=11 (338 m3)	n=55 (1,830 m3)	n=52 (1,723 m3)
Family / Stage	MAY	JUNE	JULY
ACIPENSERIDAE	0	1	0
YS Larvae	0	1	0
CLUPEIDAE	0	5	4
YS Larv	0	0	2
Larvae	0	5	2
CYPRINIDAE	31	669	1951
Egg	9	28	99
Prolarvae	6	447	1076
YS Larvae	16	87	708
Larvae	0	13	51
Juvinile	0	90	15
Adult	0	4	2
CATOSTOMIDAE	2	45	15
YS Larvae	2	44	7
Larvae	0	1	1
Juvinile	0	0	7
ICTALURIDAE	0	0	3
Juvinile	0	0	3
ATHERINIDAE	0	2	0
Larvae	0	2	0
CENTRARCHIDAE	0	2	9
YS Larvae	0	1	0
Larvae	0	1	0
Juvinile	0	0	9
PERCIDAE	2	0	0
Prolarvae	1	0	0
Larvae	1	0	0
SCIAENIDAE	30	582	36
Egg	24	513	32
Prolarvae	5	32	1
YS Larvae	1	37	1
Juvinile	0	0	2

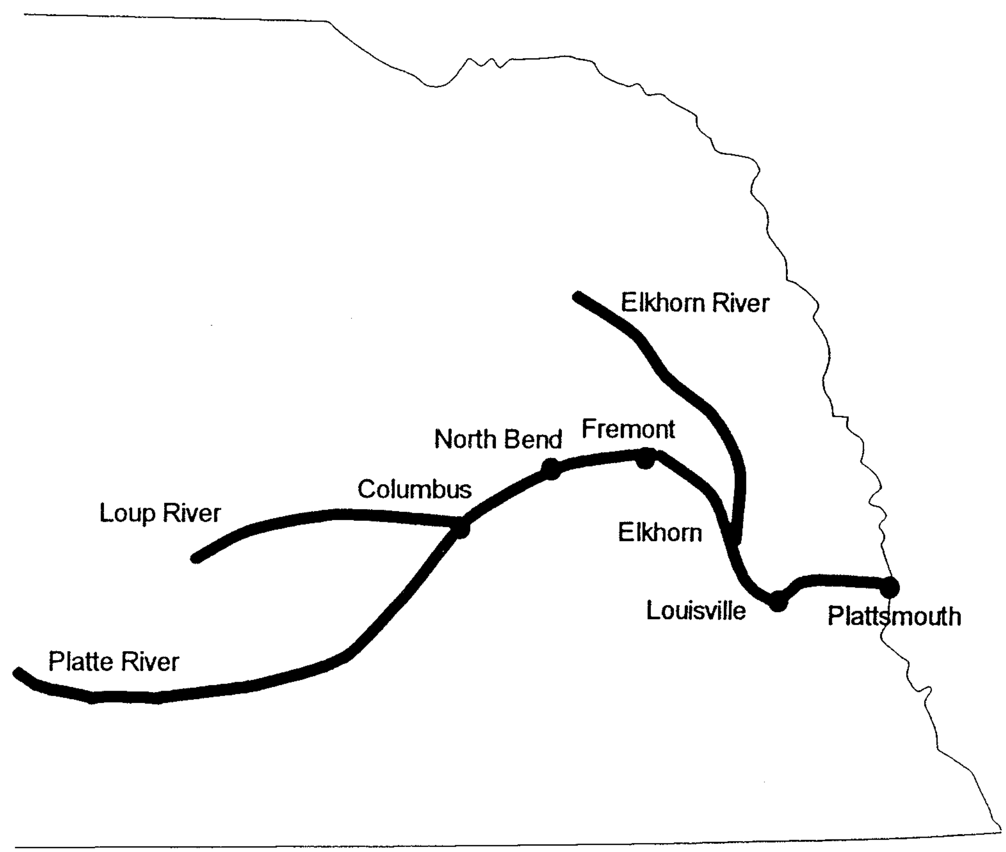

Figure 1: Sampling Sites in the Lower Platte River, Eastern Nebraska.

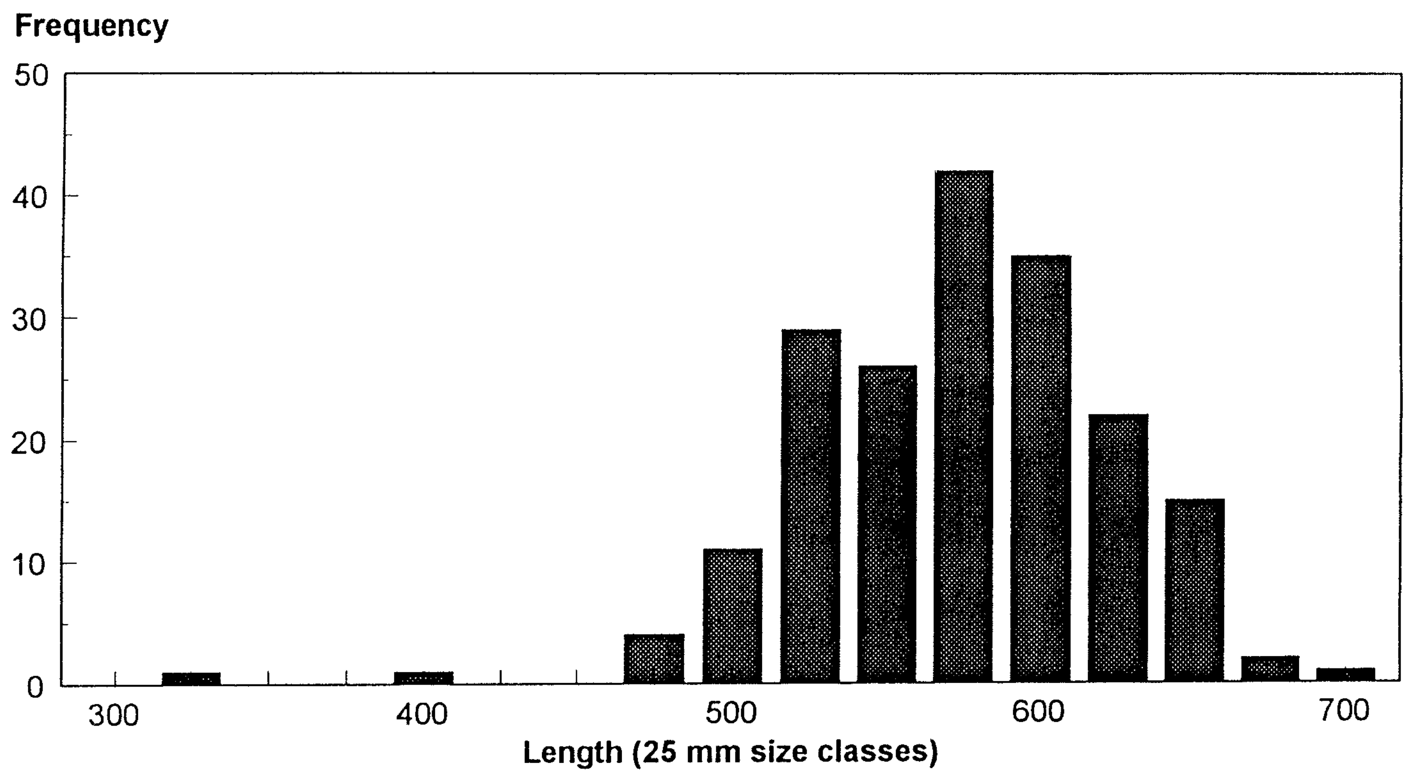

Figure 2: Length frequency distribution for shovelnose sturgeon in the lower Platte River, Nebraska.

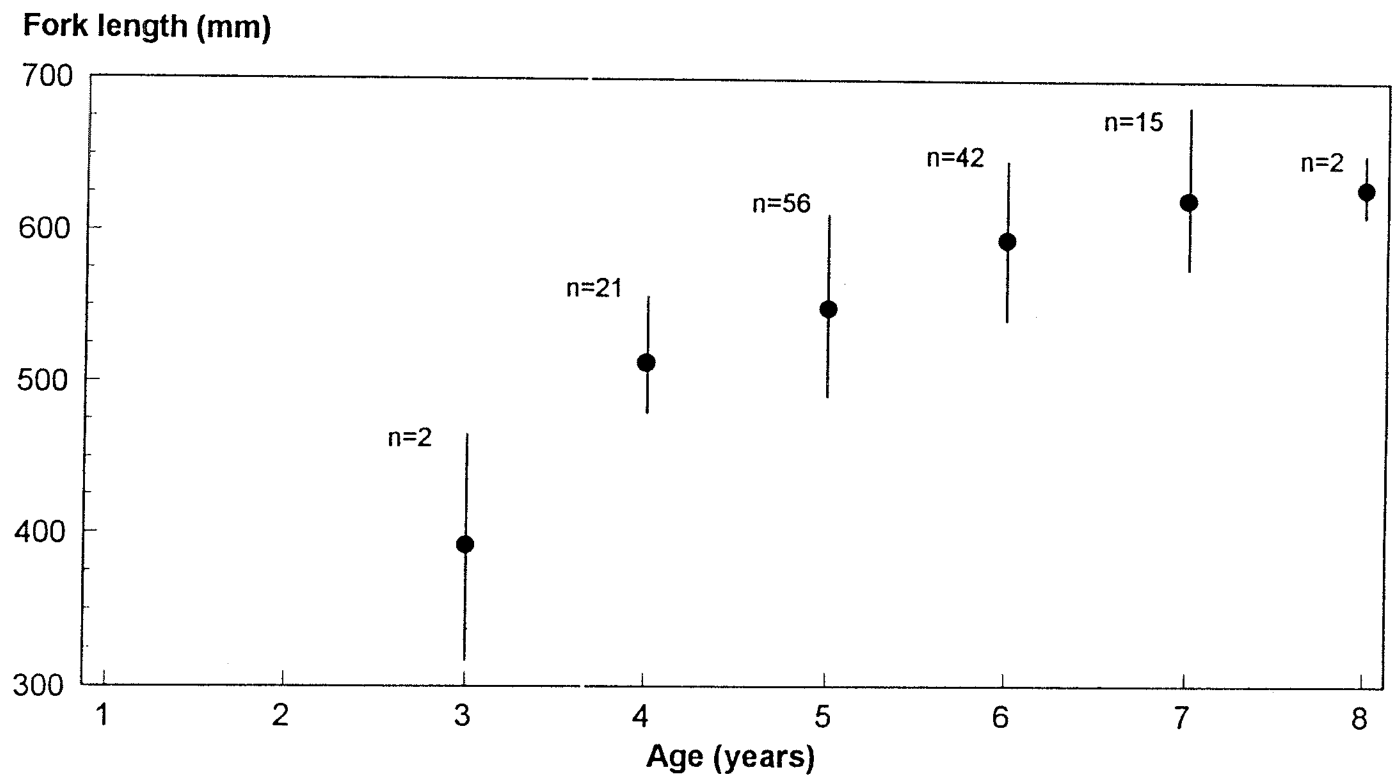

Figure 3: Means and ranges of length at each age for shovelnose sturgeon in the lower Platte River.

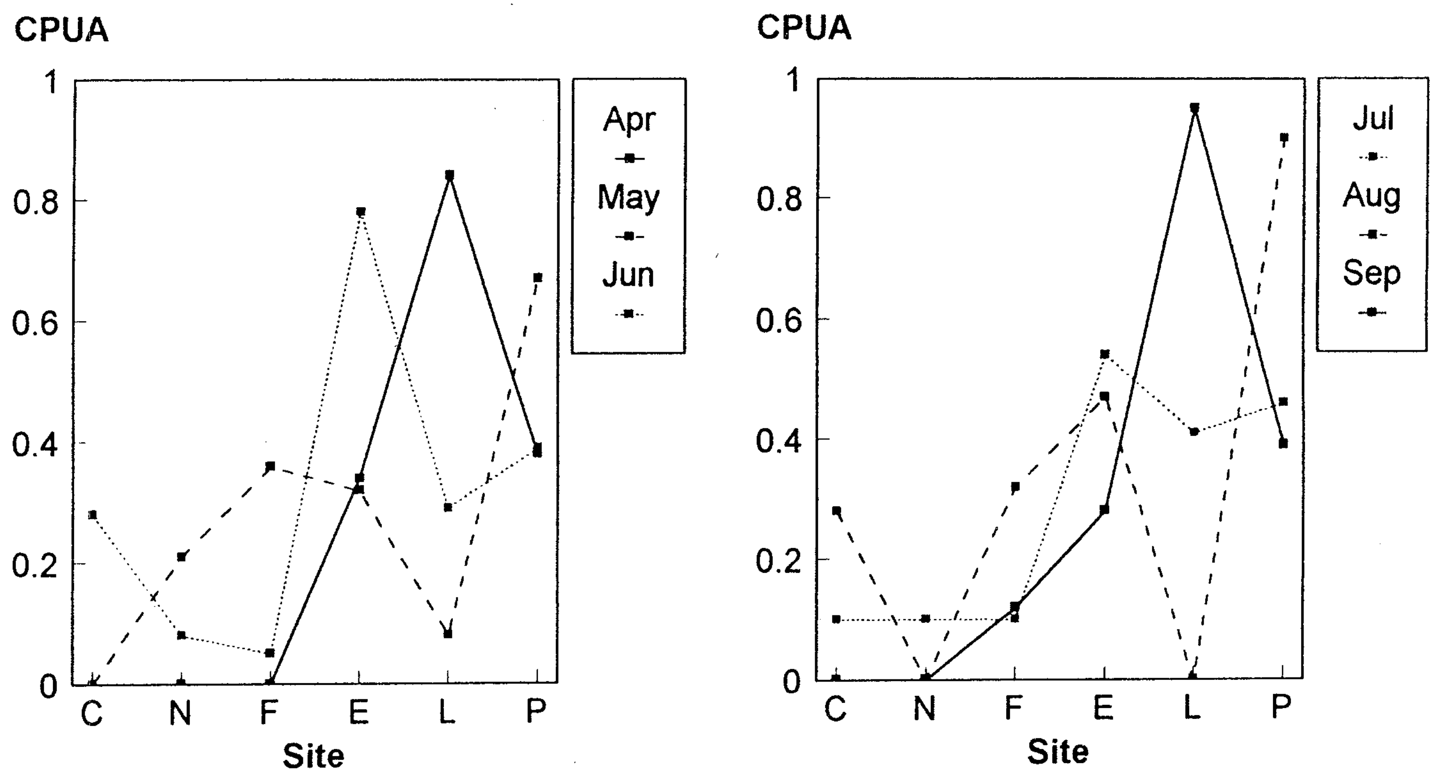

Figure 4. CPUA (number of sturgeon captured per hectare of river sampled with drifted gill nets) at six sites in the lower Platte River, from April through September, 1996.

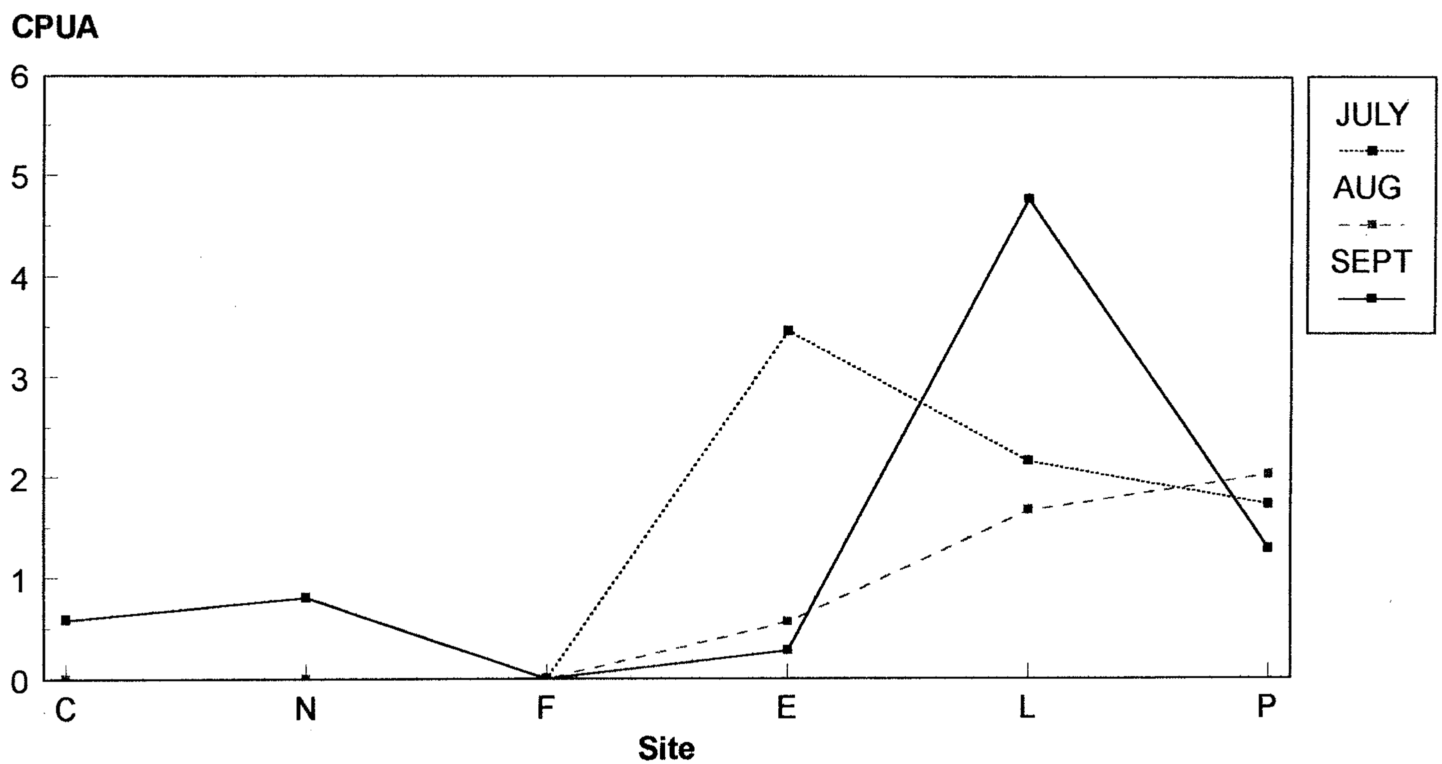

Figure 5. CPUA (number of sturgeon captured per hectare of river sampled with drifted gill nets) at each site in the lower Platte River from July through September, 1995.

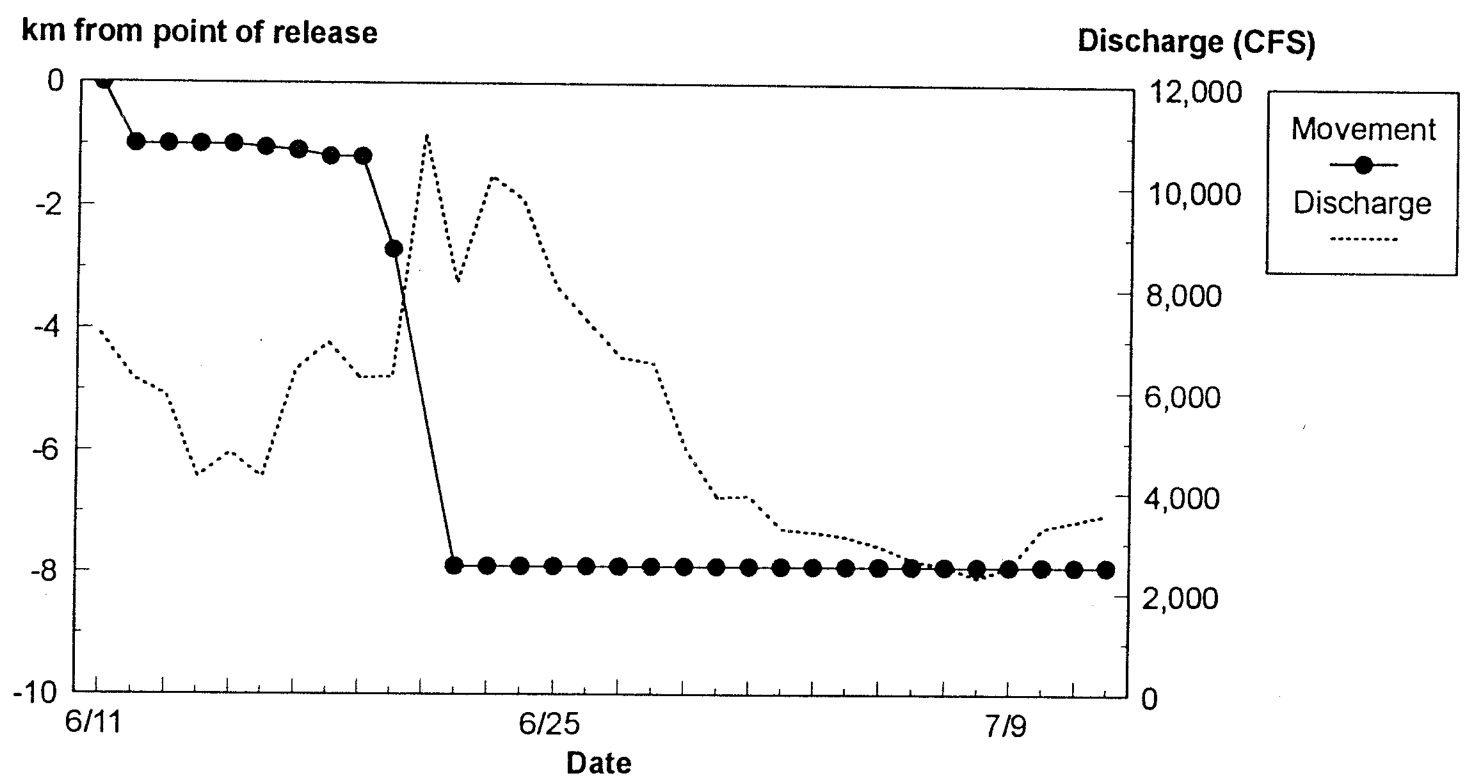

Figure 6. Movements of sturgeon #863 and daily discharge in the lower Platte River near Columbus, Nebraska during June and July, 1996.

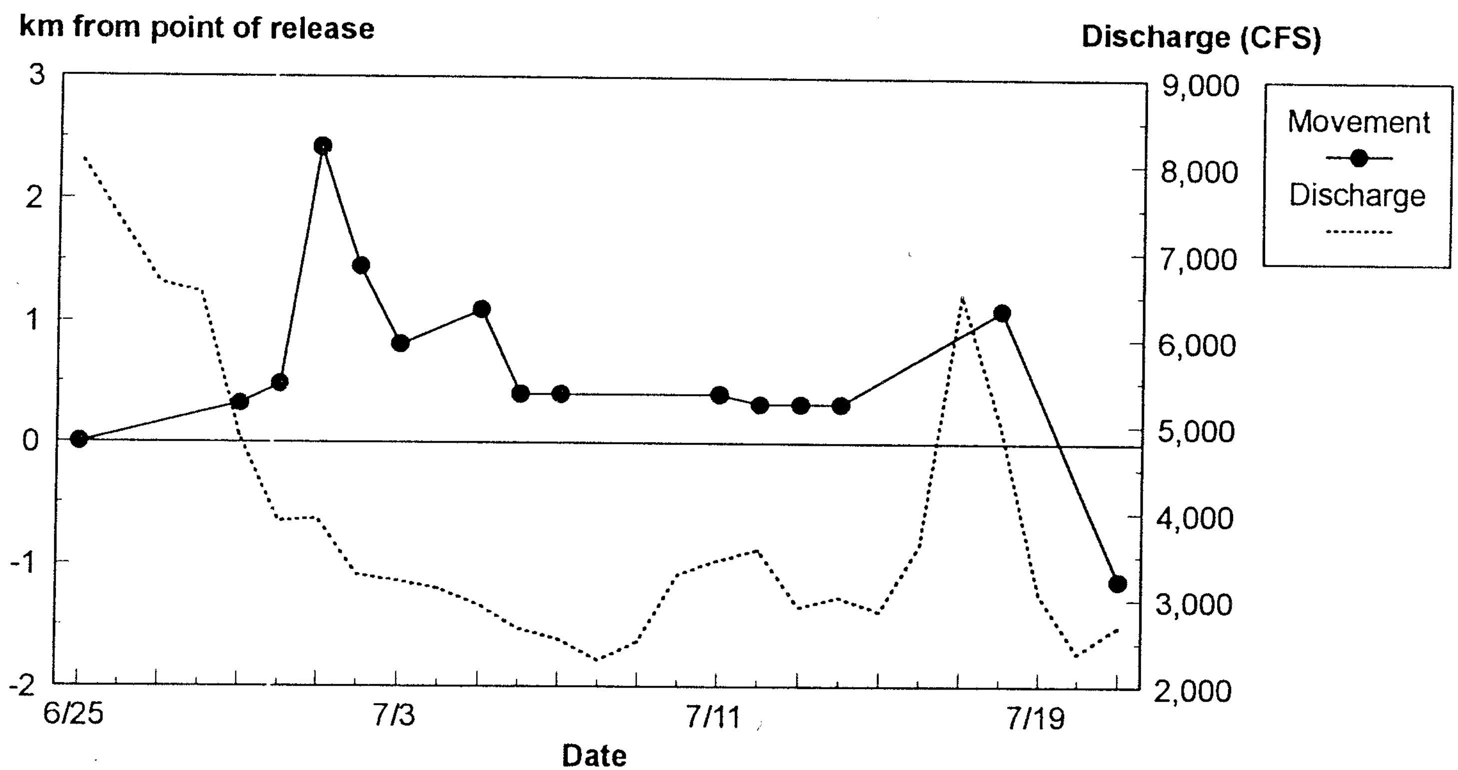

Figure 7. Movements of sturgeon #740 and daily discharge in the lower Platte River near Columbus, Nebraska during June and July, 1996.

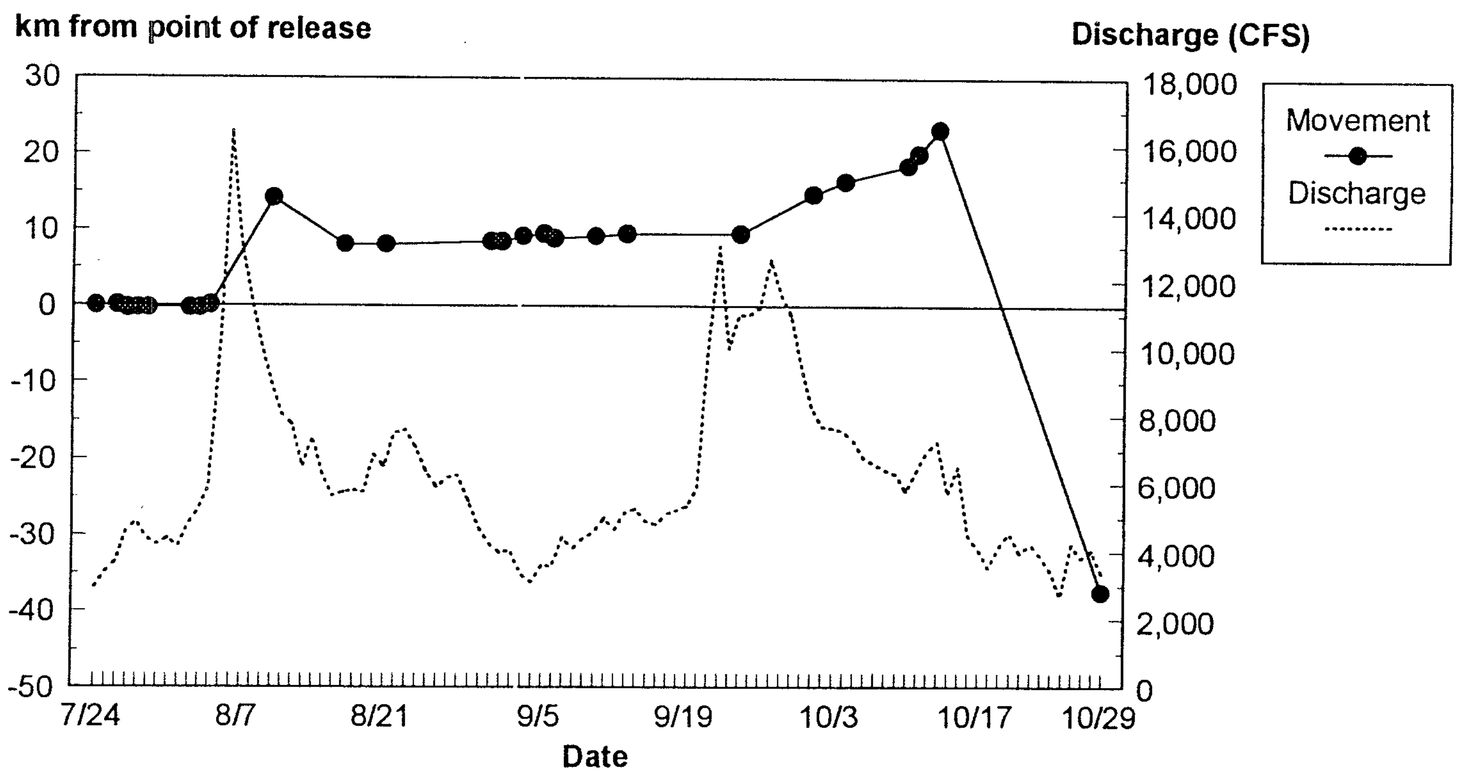

Figure 8. Movements of sturgeon #760 and daily discharge in the lower Platte River near the Elkhorn tributary from July through October, 1996.

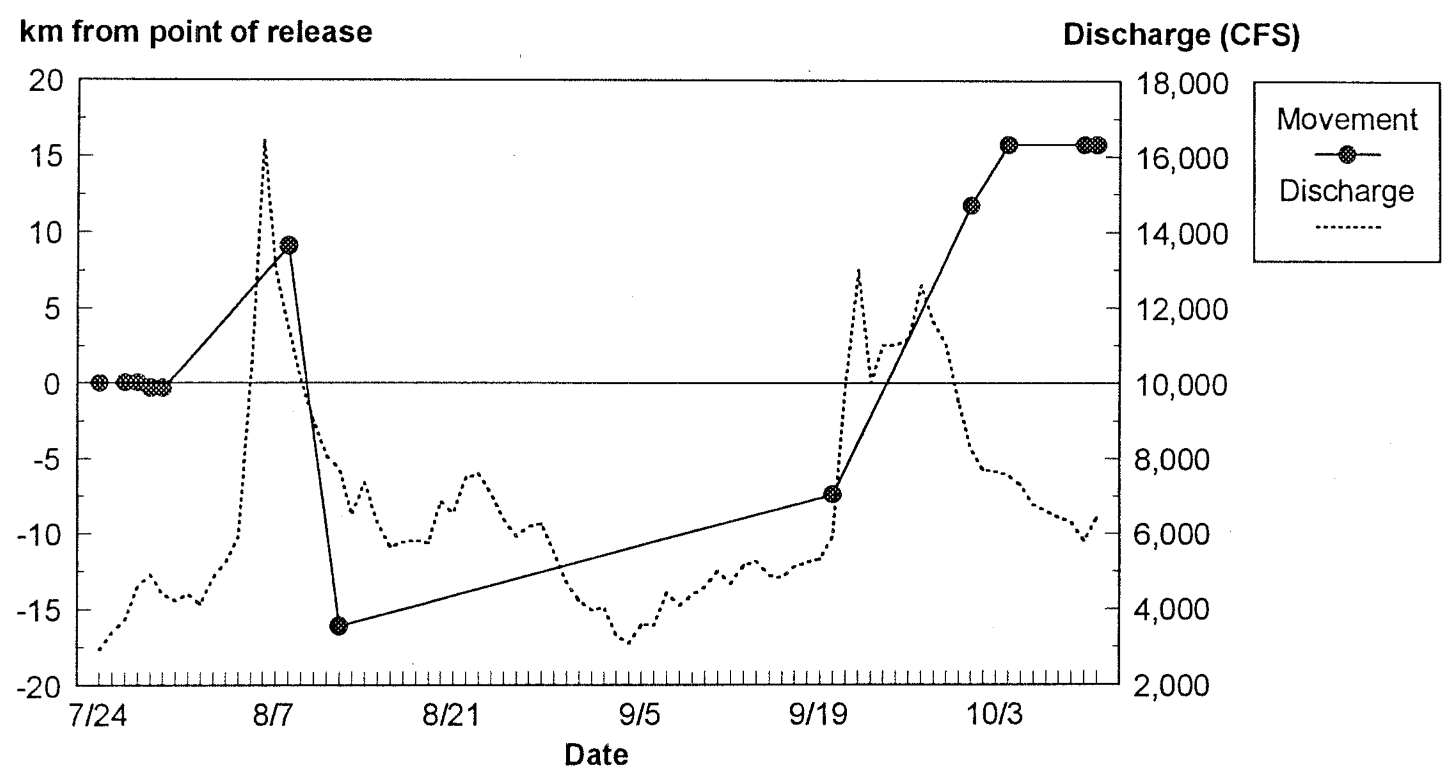

Figure 9. Movements of sturgeon #820 and daily discharge in the lower Platte River near the Elkhorn tributary from July through October, 1996.

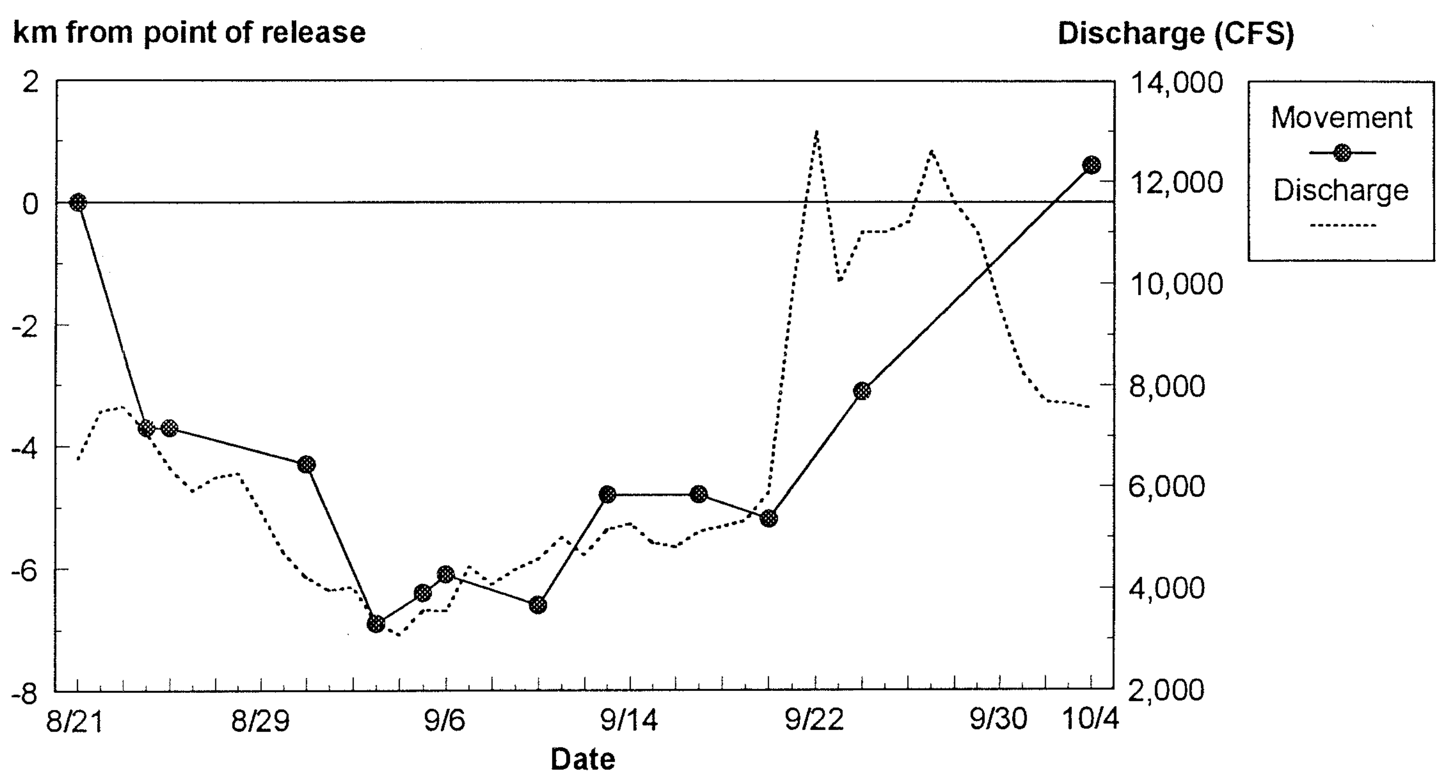

Figure 10. Movements of sturgeon #800 and daily discharge in the lower Platte River near the Elkhorn tributary from August through October, 1996.

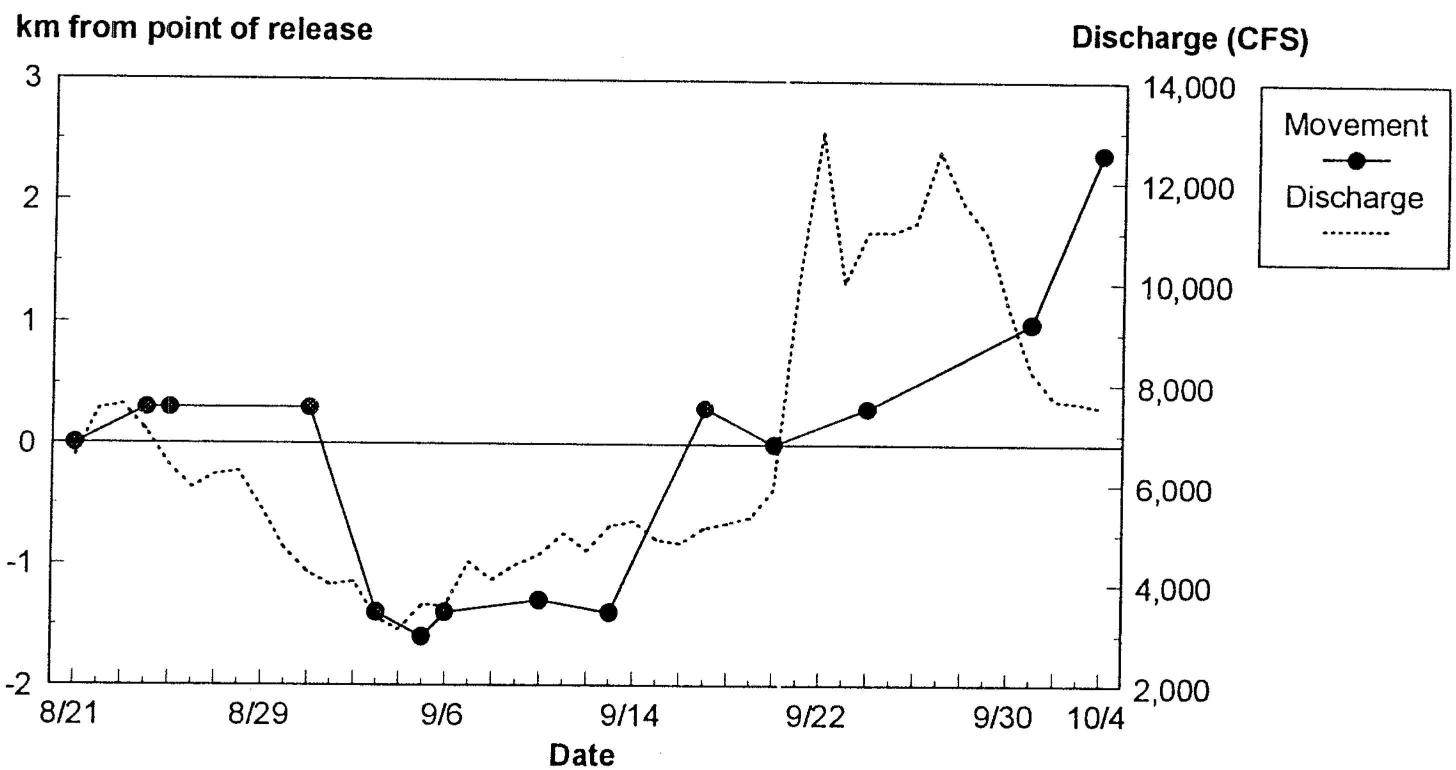

Figure 11. Movements of sturgeon #840 and daily discharge in the lower Platte River near the Elkhorn tributary from August through October, 1996.

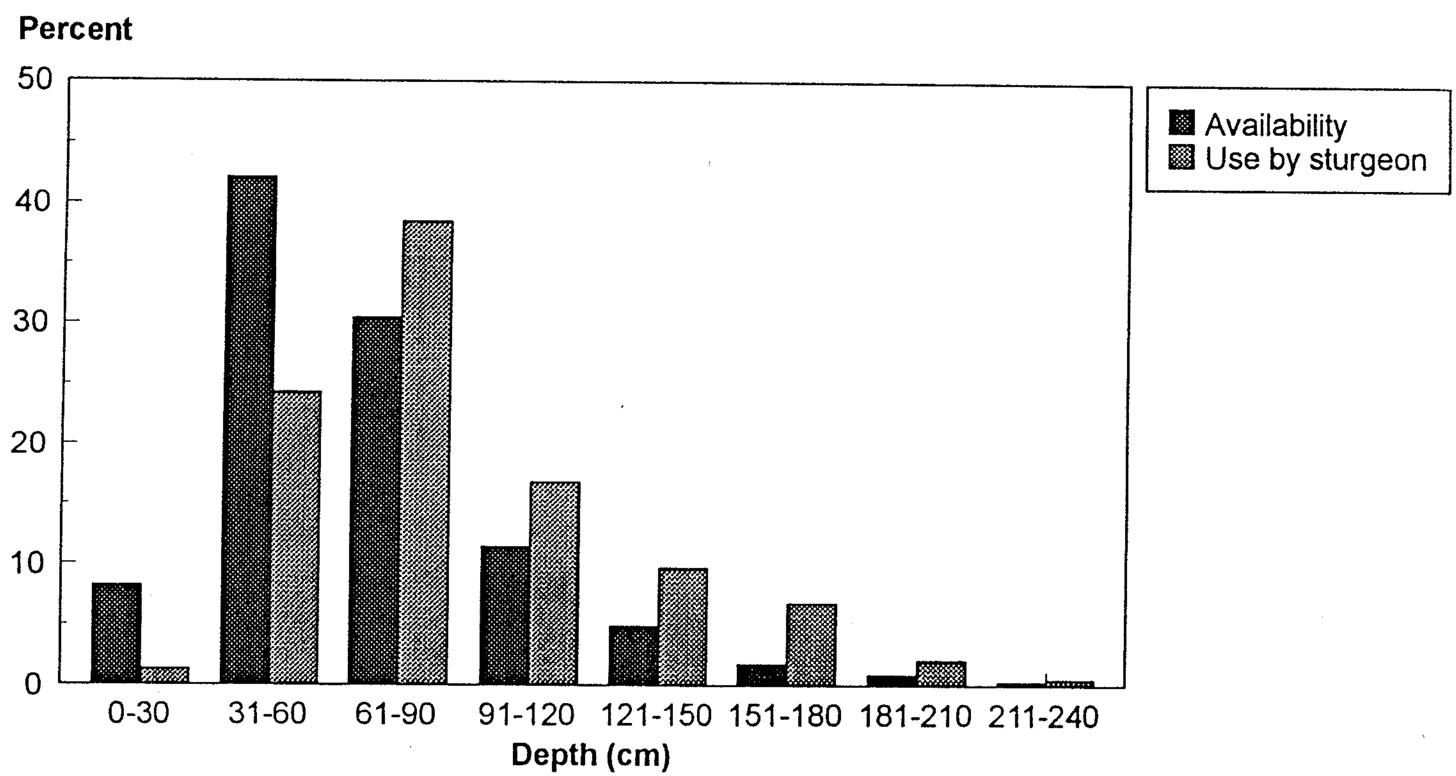

Figure 12. Percent availability and use by shovelnose sturgeon for depth in the lower Platte River during 1995 and 1996.

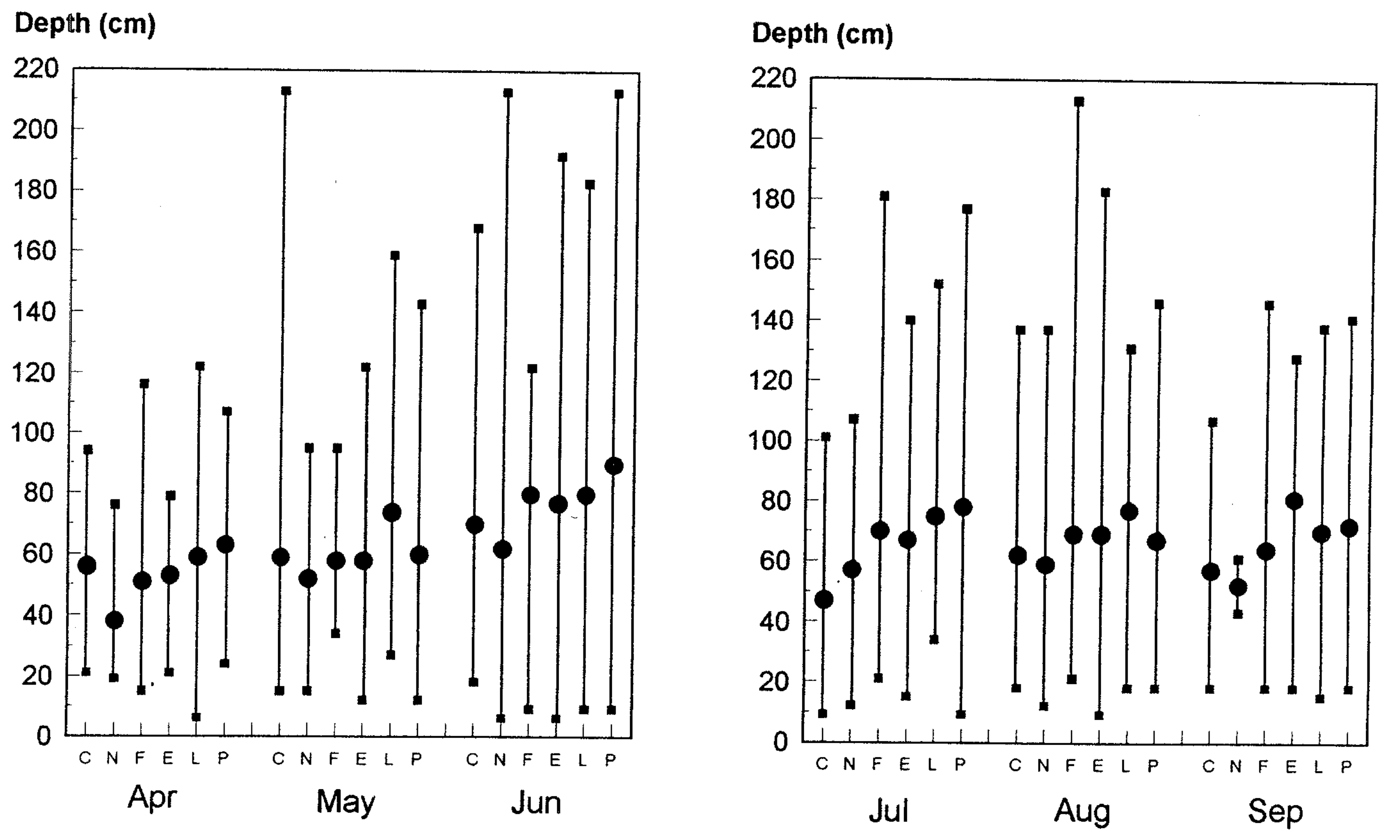

Figure 13. Range and means for depths sampled at each site from April through September, 1996.

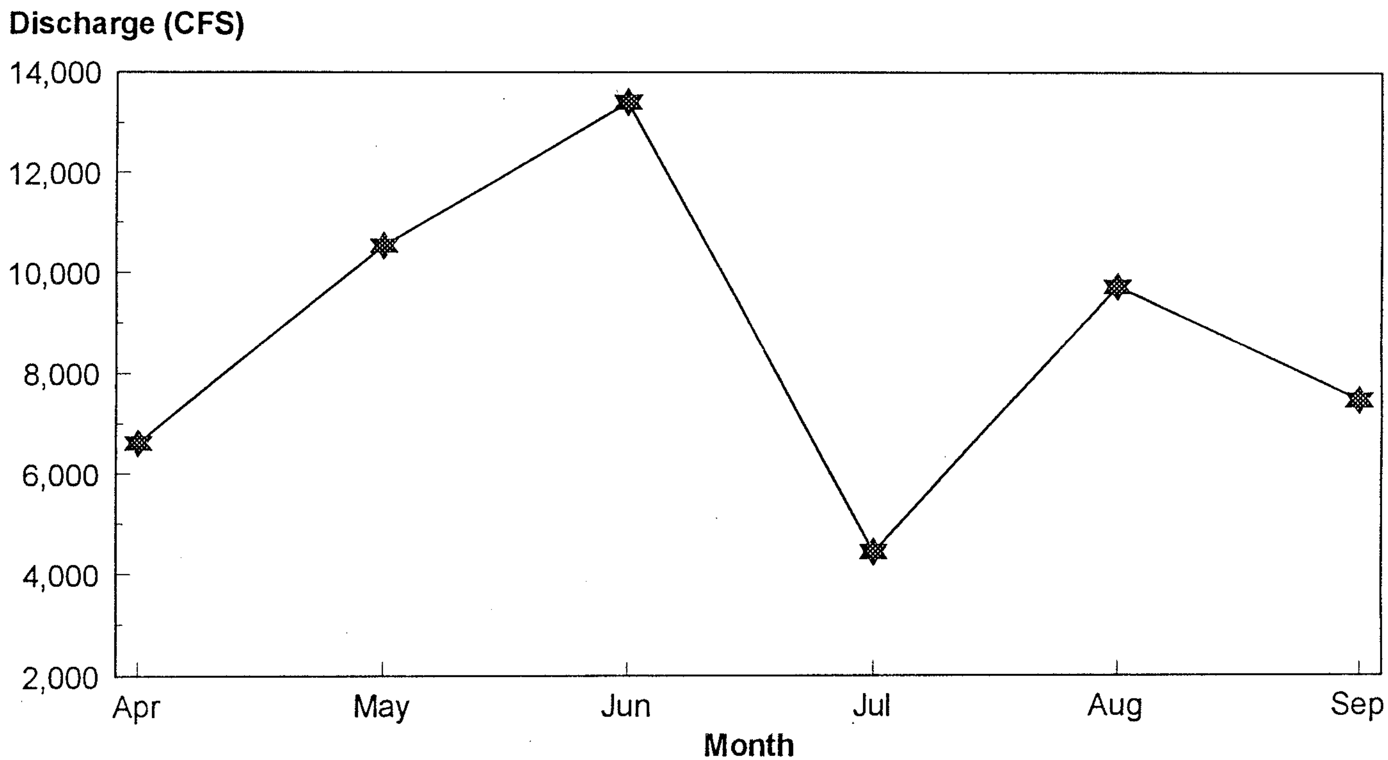

Figure 14: Monthly means for daily discharge in the lower Platte River from April through September, 1996.

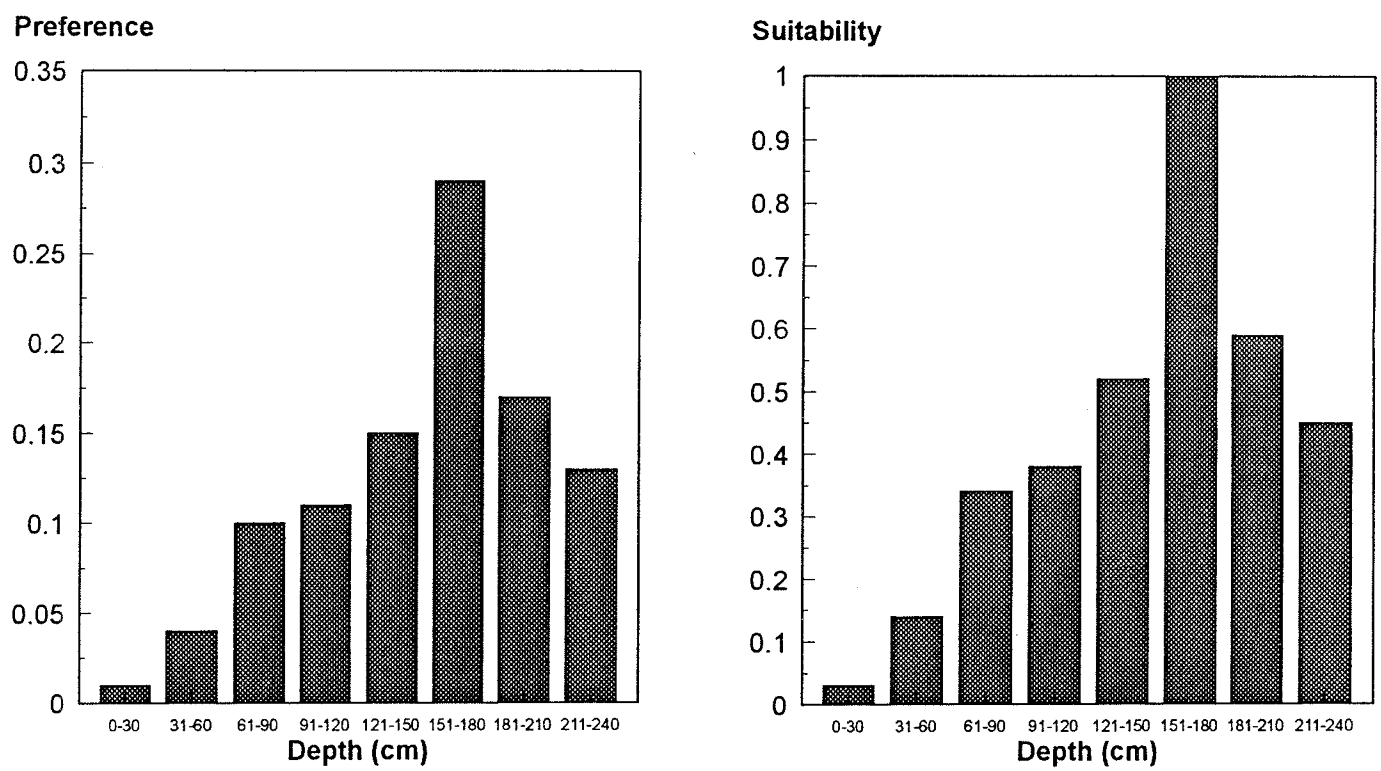

Figure 15. Depth preference and suitability for shovelnose sturgeon in the lower Platte River, Nebraska.

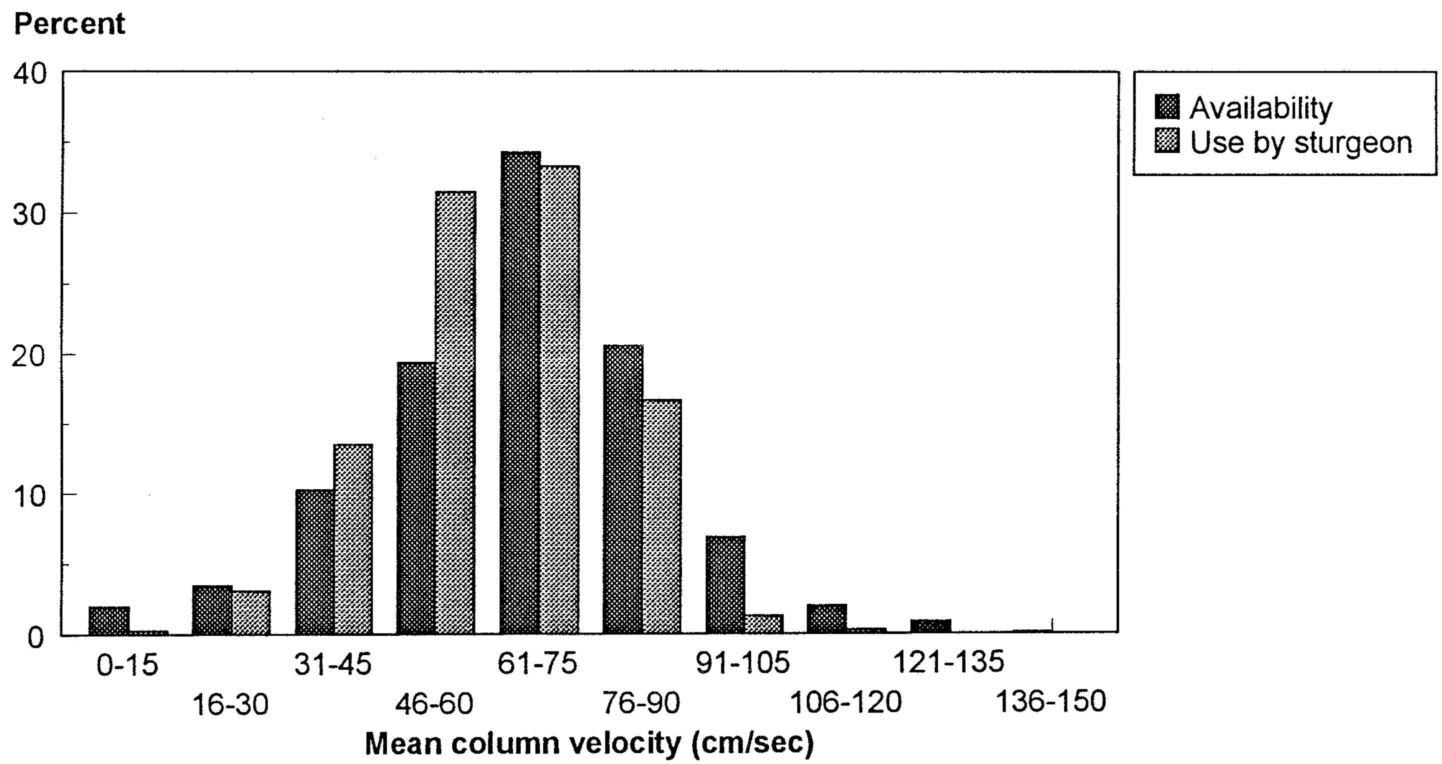

Figure 16. Percent availability and use by shovelnose sturgeon for mean column velocity in the lower Platte River during 1995 and 1996.

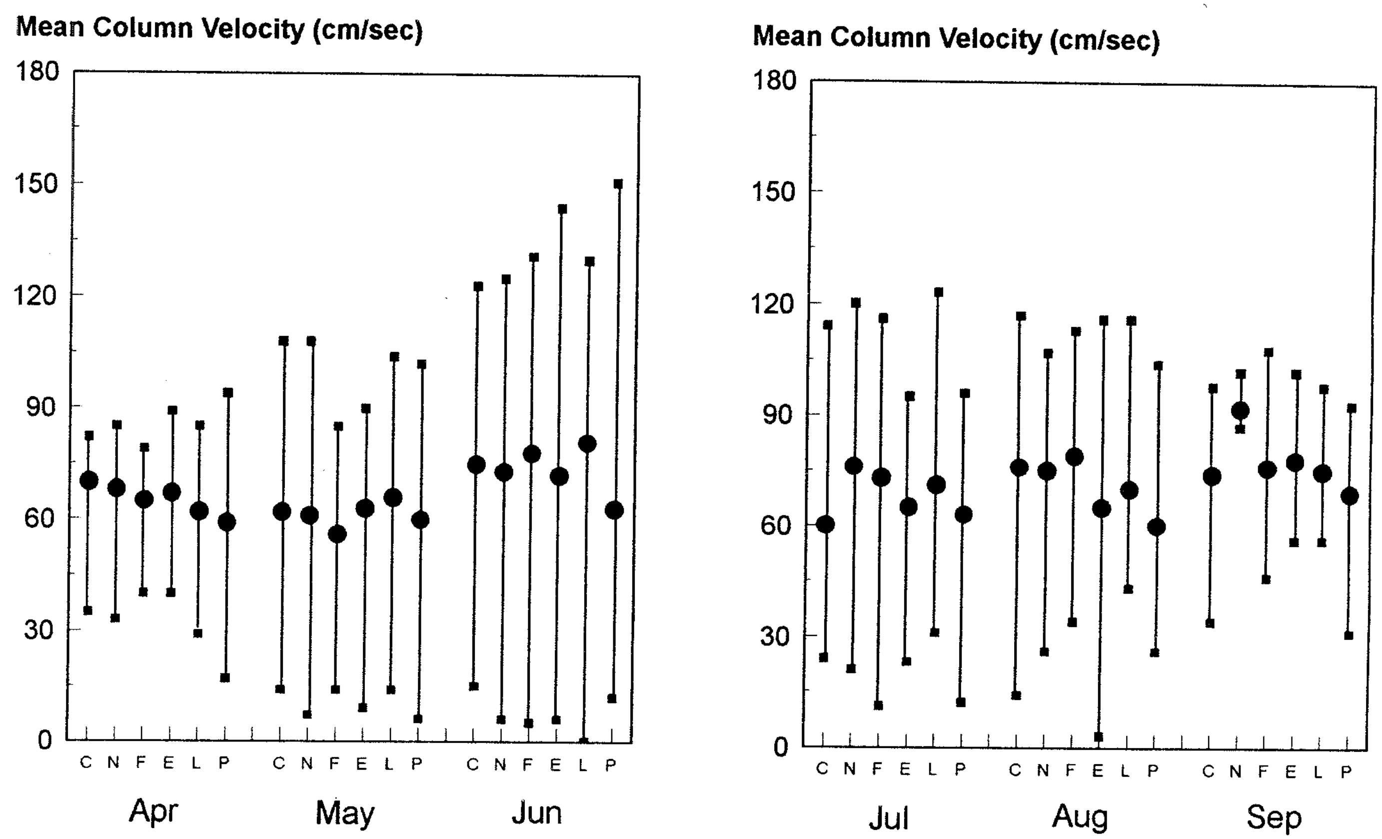

Figure 17. Range and means for mean column velocities sampled at each site from April through September, 1996.

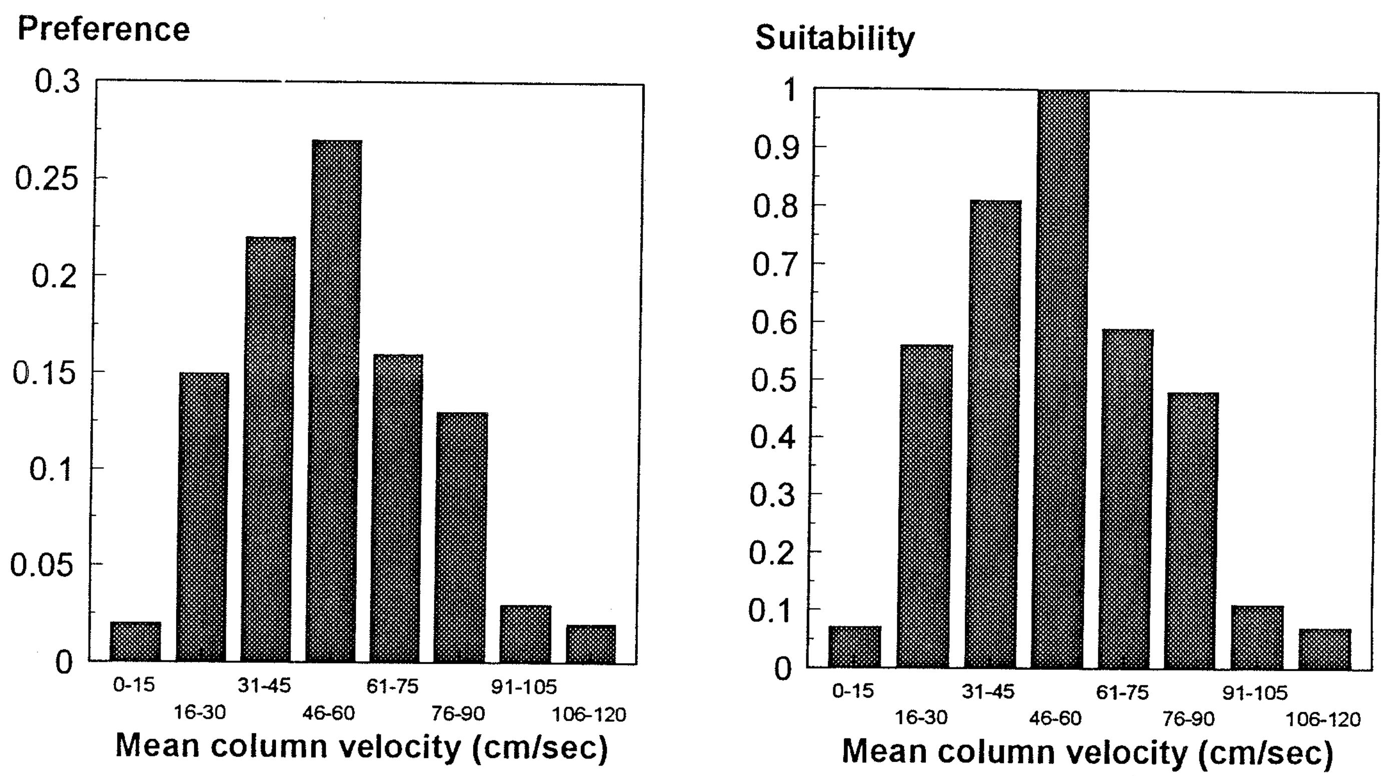

Figure 18. Mean column velocity preference and suitability for shovelnose sturgeon in the lower Platte River, Nebraska.

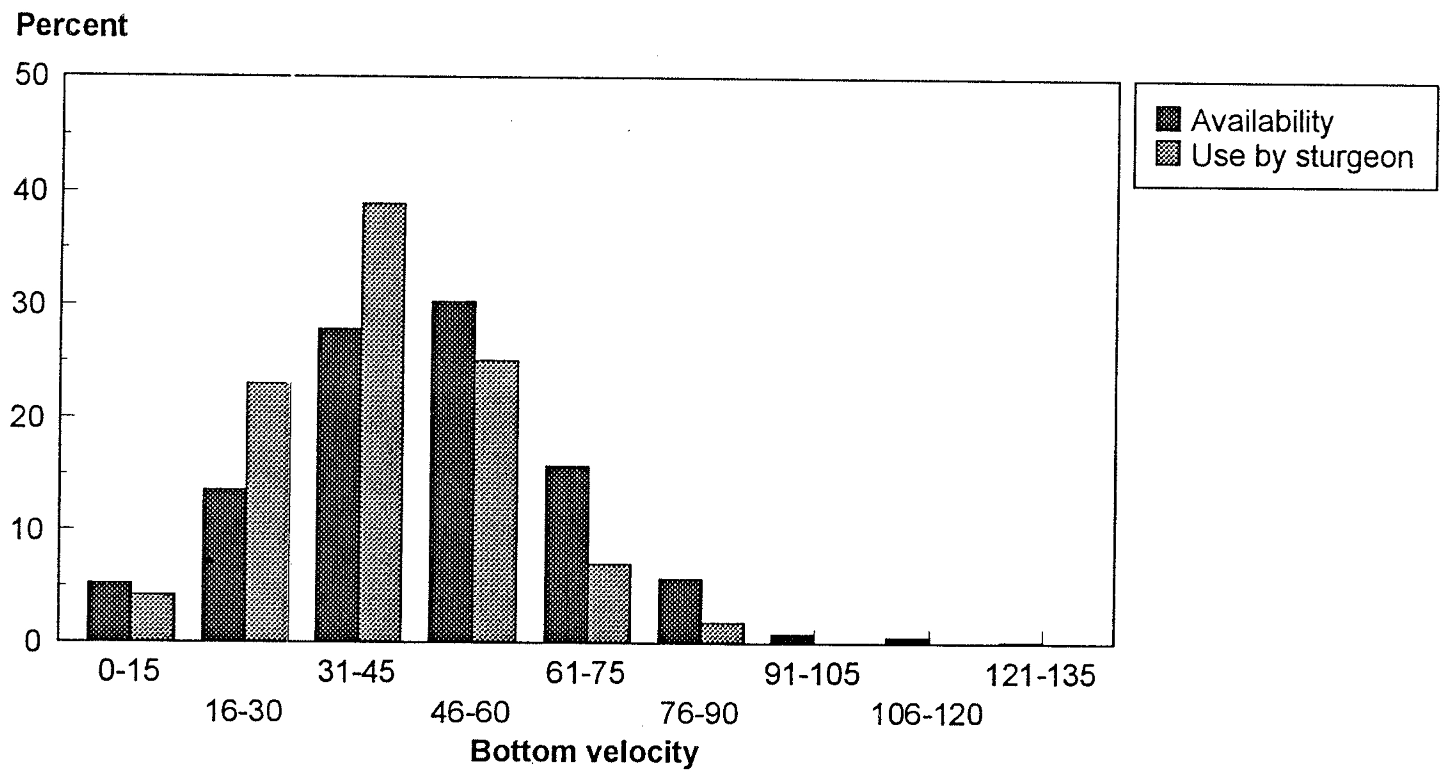

Figure 19. Percent availability and use by shovelnose sturgeon for bottom velocity in the lower Platte River during 1995 and 1996.

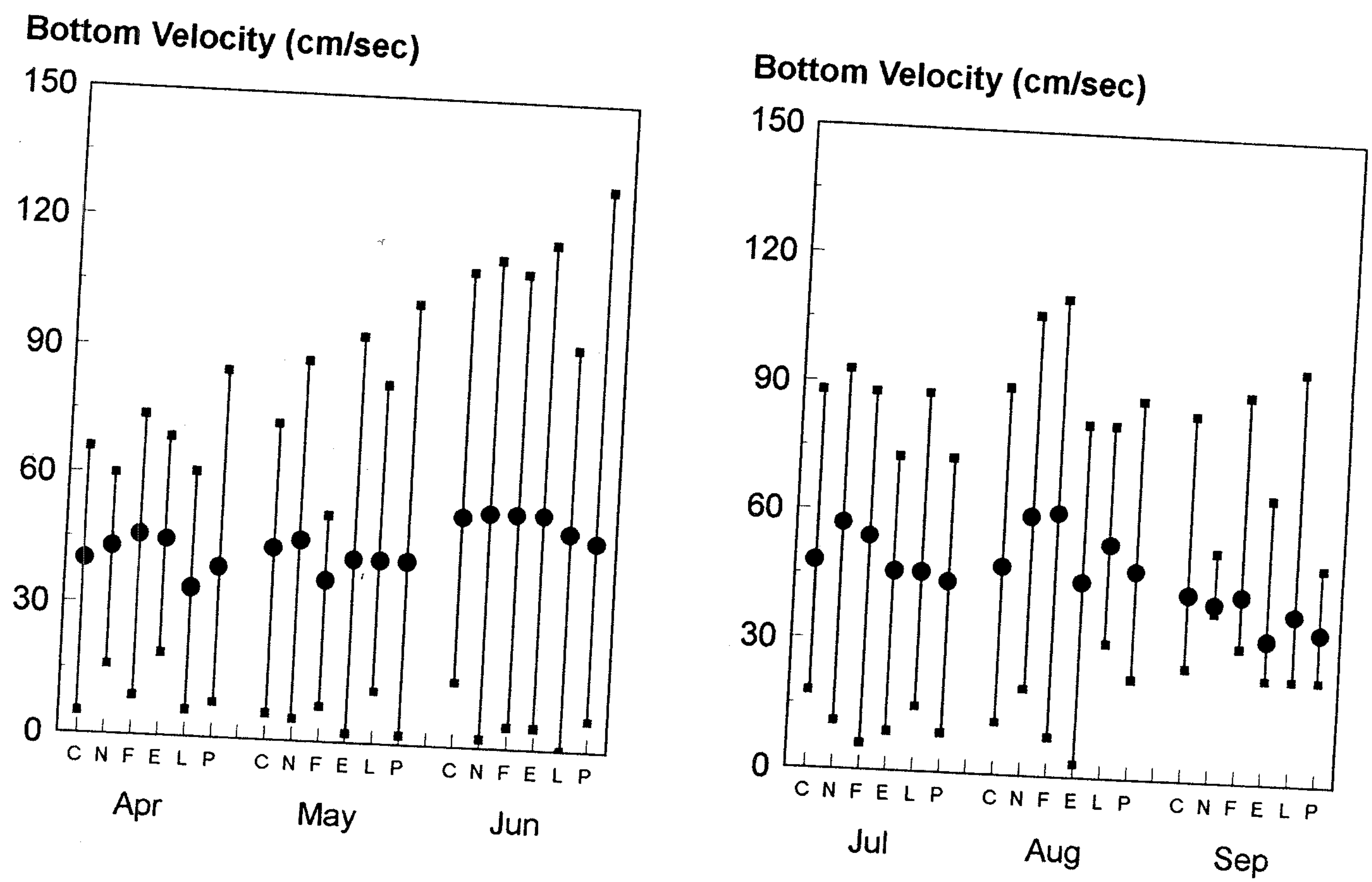

Figure 20. Range and means for bottom velocities sampled at each site from April through September, 1996.

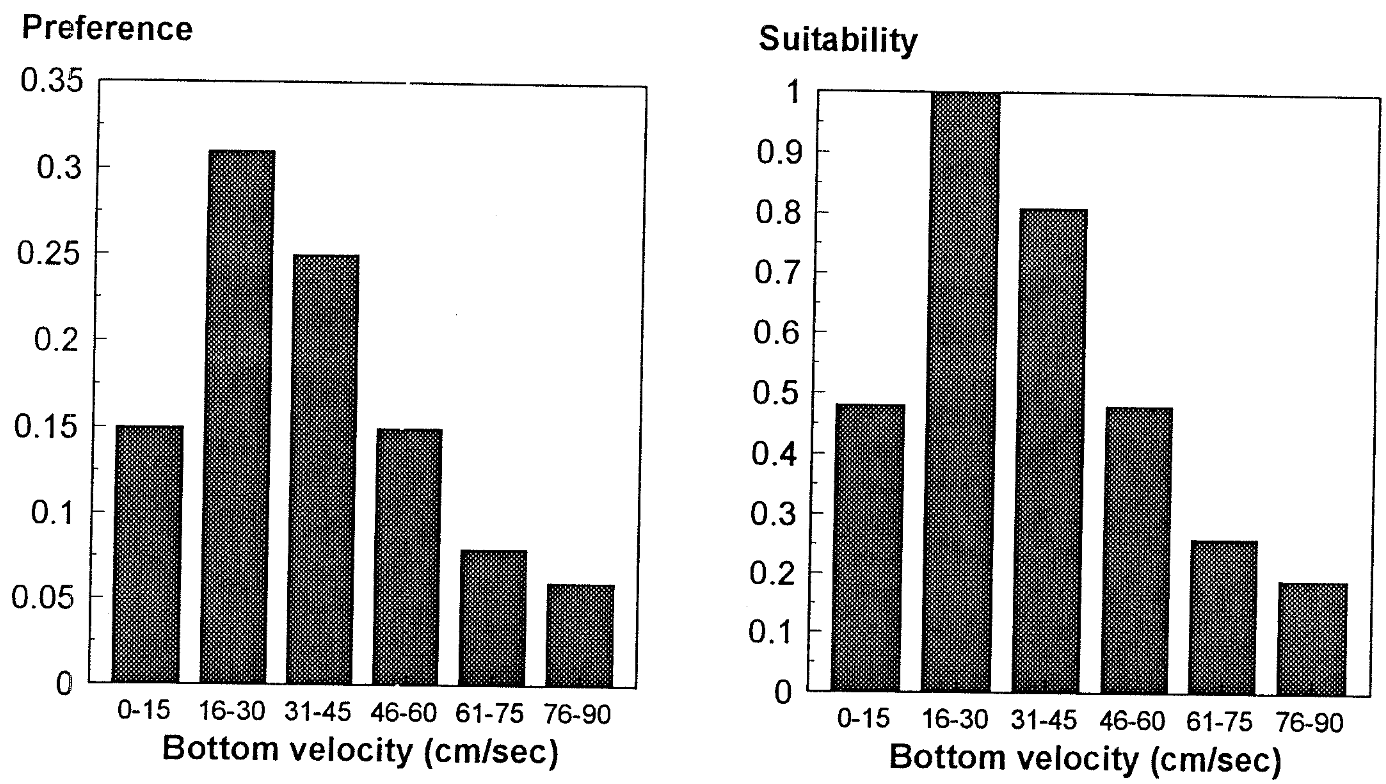

Figure 21. Bottom velocity preference and suitability for shovelnose sturgeon in the lower Platte River, Nebraska.

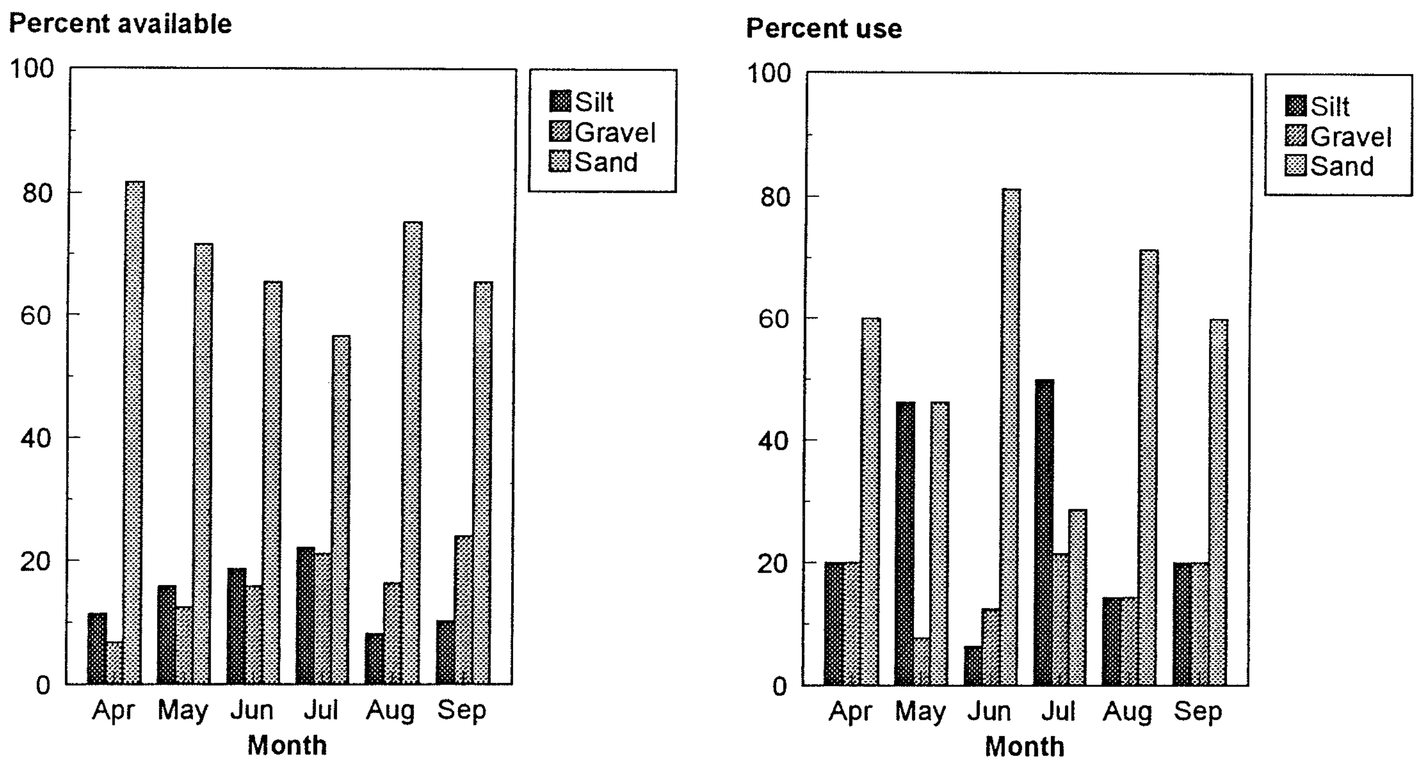

Figure 22. Percent availability and use of substrates by shovelnose sturgeon in the lower Platte River from April through September, 1996.

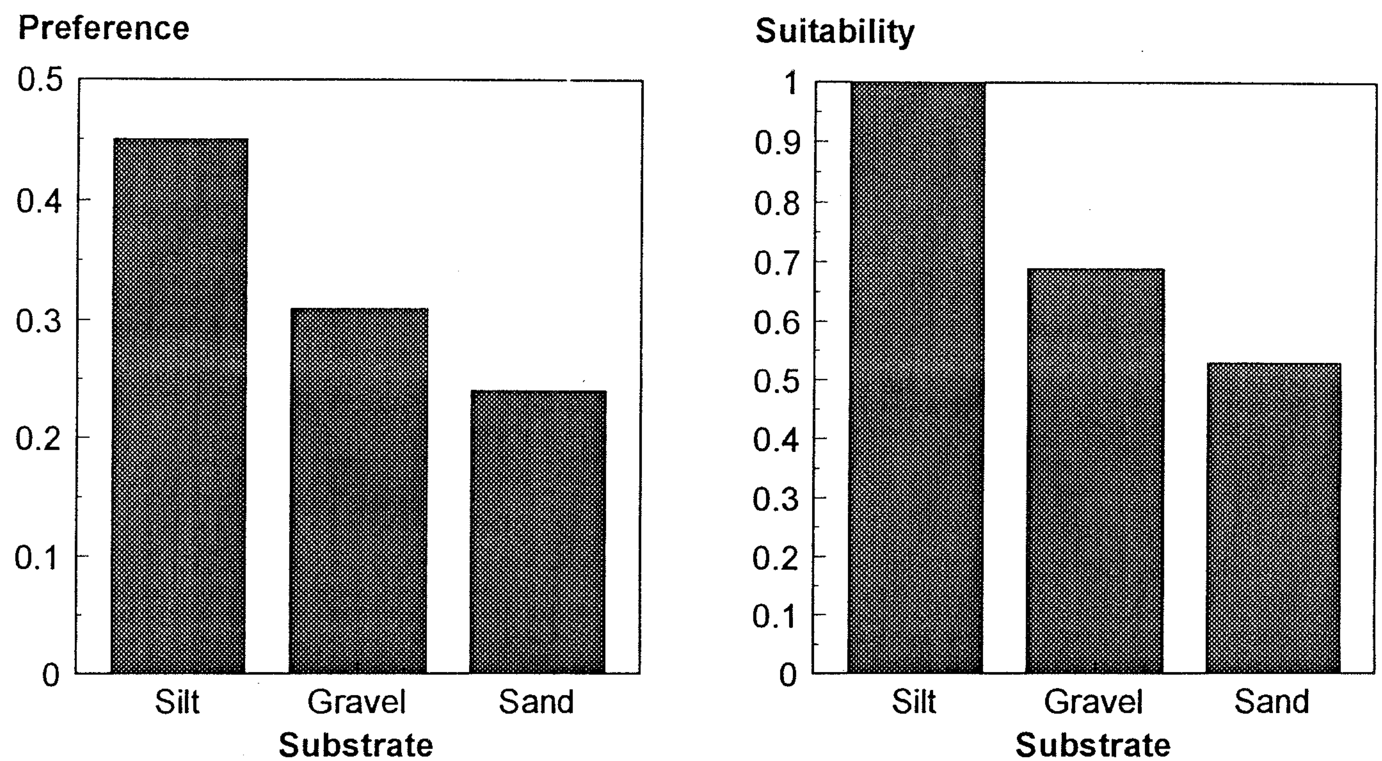

Figure 23. Substrate preference and suitability for shovelnose sturgeon in the lower Platte River, Nebraska.

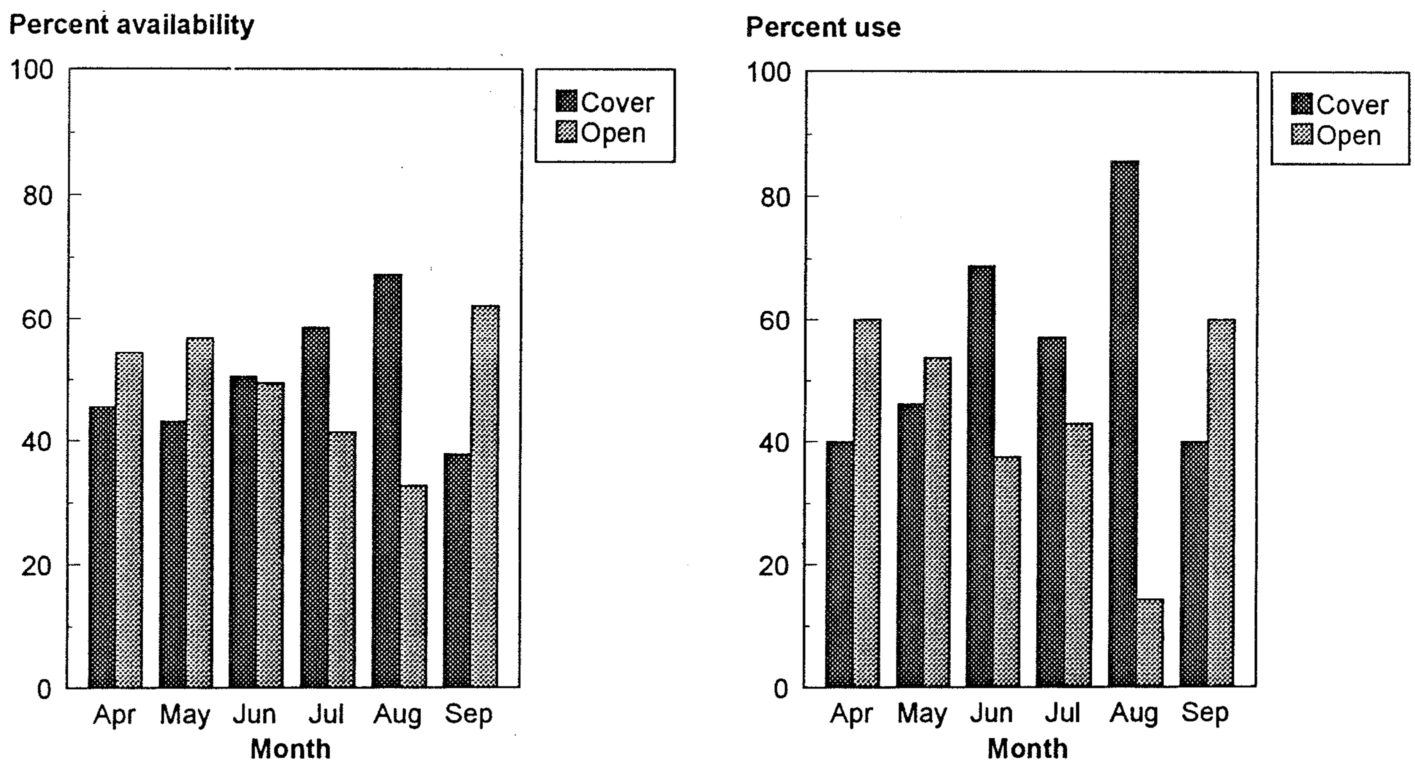

Figure 24. Percent availability and use of cover and open channels by shovelnose sturgeon in the lower Platte River from April through September, 1996.

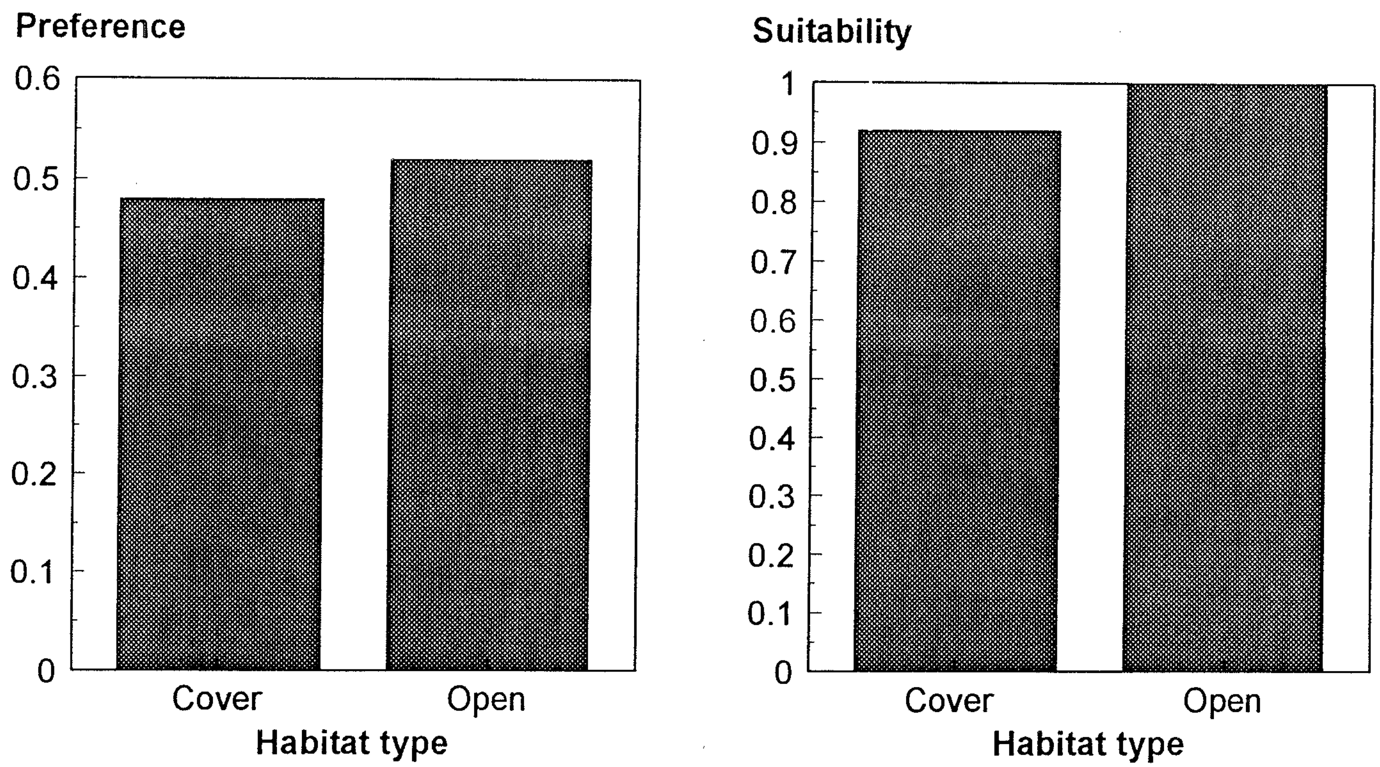

Figure 25. Cover and open channel preference and suitability for shovelnose sturgeon in the lower Platte River, Nebraska.

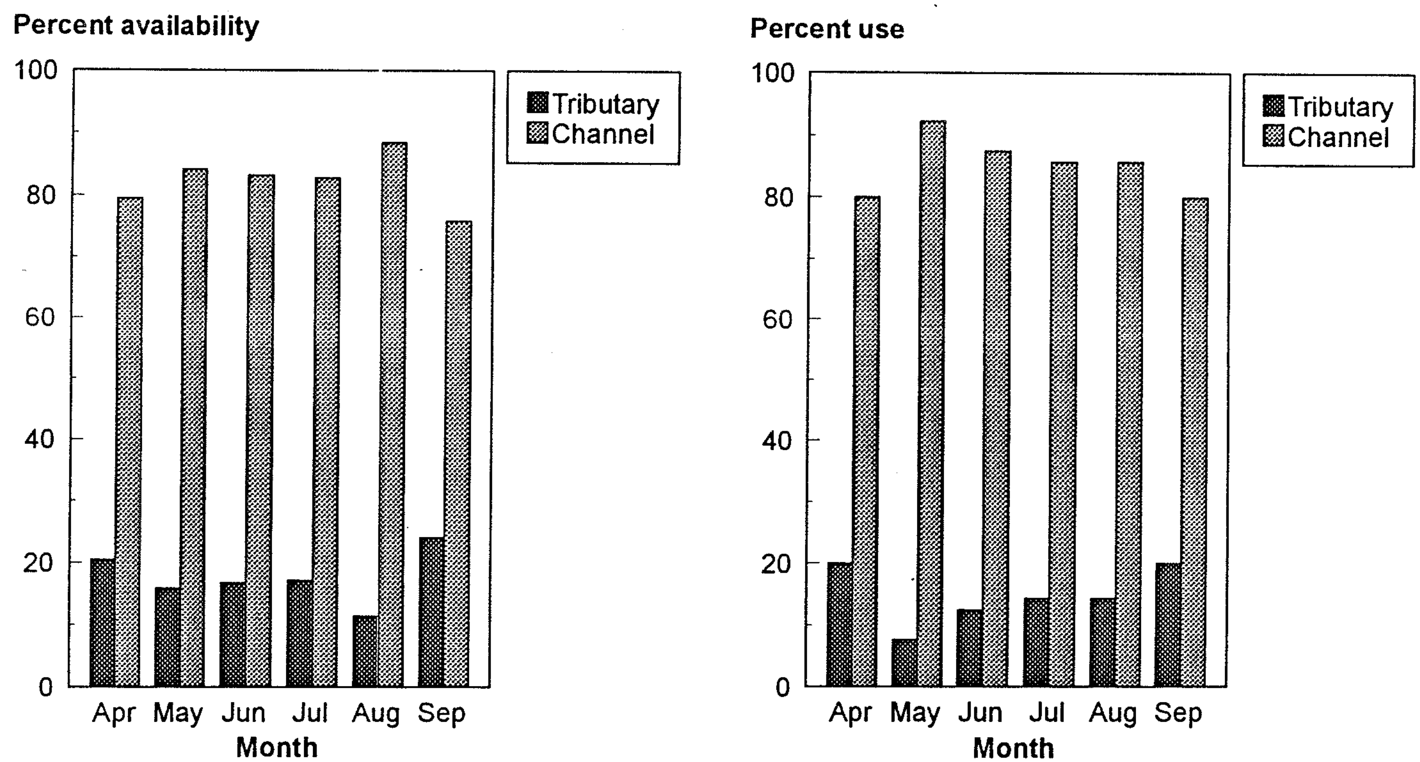

Figure 26. Percent availability and use of tributary and river channels by shovelnose sturgeon in the lower Platte River from April through September, 1996.

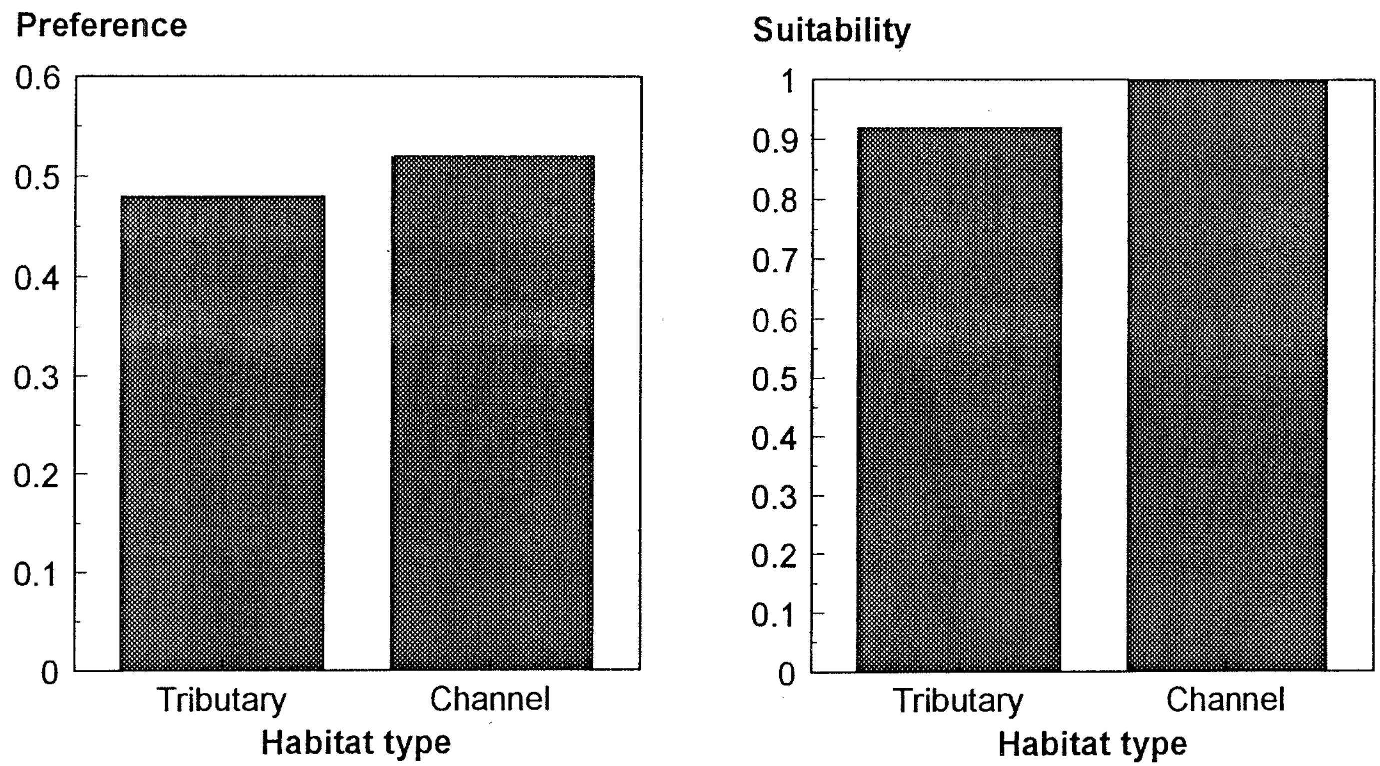

Figure 27. Tributary and river channel preference and suitability for shovelnose sturgeon in the lower Platte River, Nebraska.

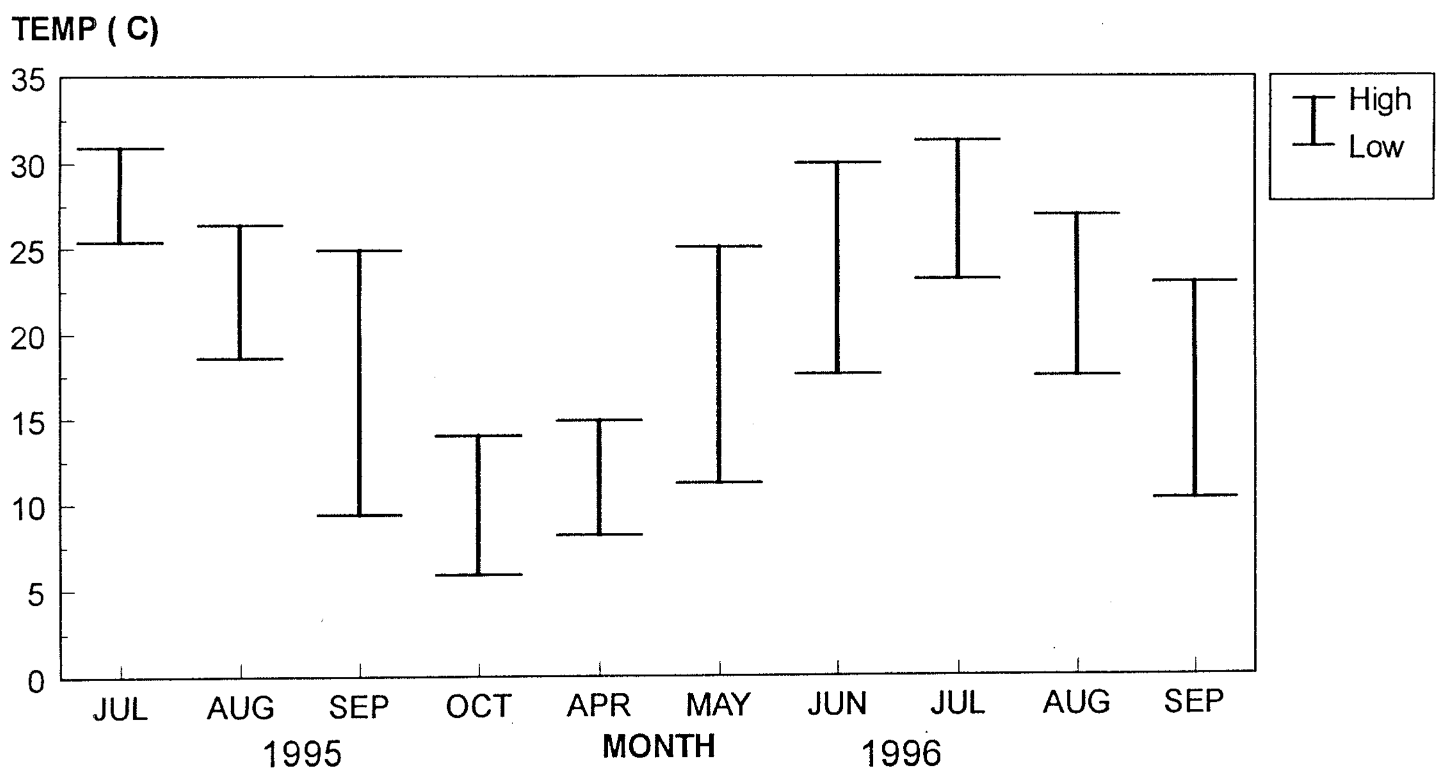

Figure 28. Range of water temperatures recorded in the lower Platte River from July through October, 1995 and April through September, 1996.

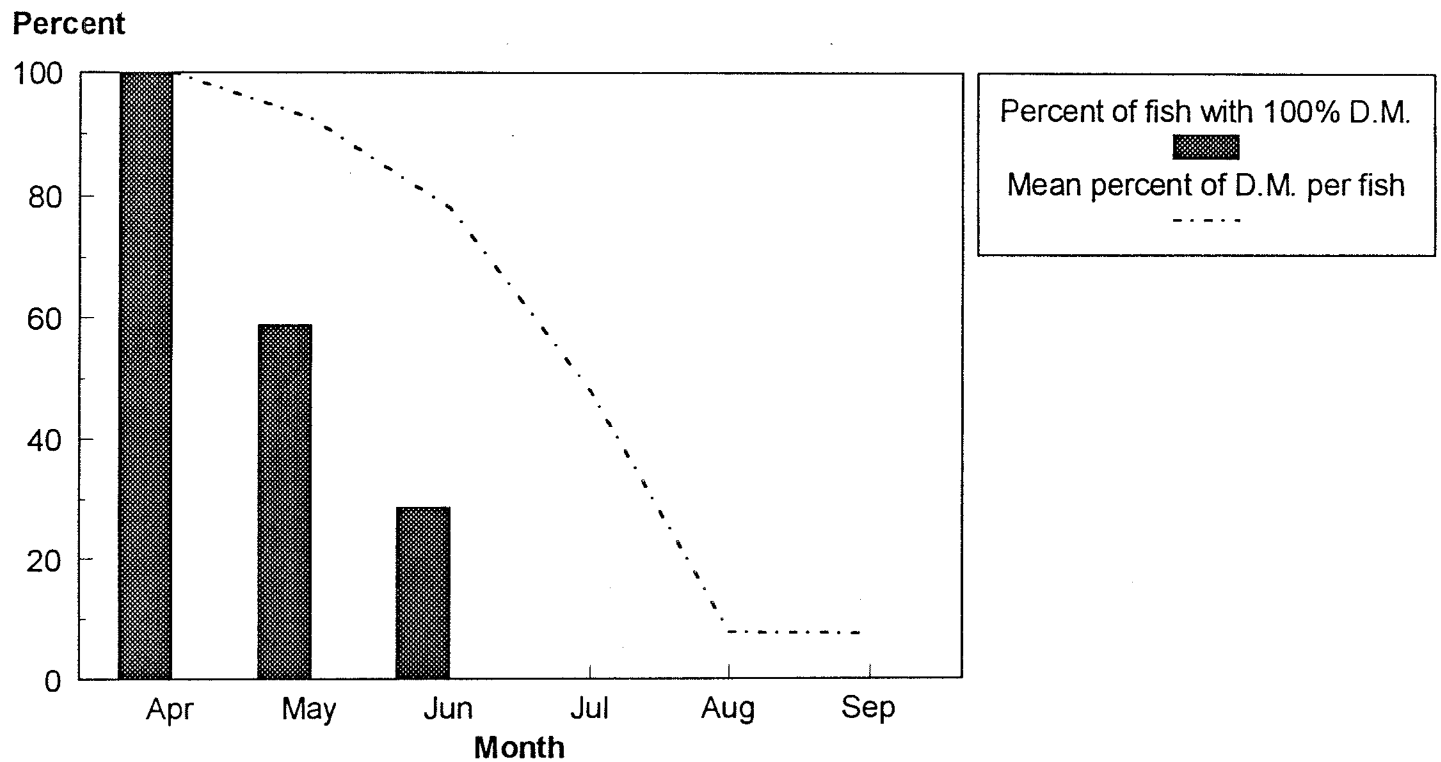

Figure 29. Percent of fish with 100% digested material and mean percent of digested material per fish from April through September, 1996.